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EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

his "Studies of Glaciers" appeared in 1840, and his "Glacial System" in 1847.

For eight successive summers Agassiz and Desor lived upon the glacier of the Aar, and each summer ascended, mostly for the first time, one or more of the peaks of the Oberland. With two friends and four guides they were the first to stand on the summit of the Jungfrau.

The great flat rock in the middle of the medial moraine of the glacier of the Aar, pictures of which are so familiar to all readers of books treating of the glacial phenomena of the Alps, was called the "Hotel des Neufchatelois," and during its slow majestic descent of the valley it entertained more celebrities, and listened to more scientific talk than any other house in Europe. All the world of science bent its steps, summer after summer, to this unique council chamber in which caroused and debated and slumbered side by side Agassiz, Desor, Vogt, Duchatelier, Nicollet, Pourtales, Coulon, De Pury, Dolfus-Ausset and their innumerable friends and visitors.

Perilous were the undertakings plotted beneath and executed from this alpine boulder on the moving ice; and exciting beyond the common text of scientific publication are the published descriptions of the first ascent of the Schreckhorn, the first ascent of the Jungfrau, and especially the first ascent of the terrible Galenstoc during which the son of Dolfus-Ausset lost his life.

Among the later comers was James Forbes, who, having learned from the veterans of the glacier of the Aar all that close and long and repeated observations could impart, established himself on the Mer de Glace, repeated and verified their data, and then returned to England and anticipated their conclusions by publishing his own celebrated book on the formation and movement of the ice.

Vogt also settled in Neufchâtel, but not until 1839, and assisted Agassiz for five years in natural history, especially in the preparation of his work on the fresh water fishes. Vogt published in 1842 his Geburtshelferkrote, and in 1843 his own book entitled "In the Mountains and on the Glaciers." Vogt then went to Paris (in 1844) and stayed until 1846, when he was appointed to a chair in his native city of Giessen. But the troubles of 1848 breaking out, he became again a political exile, and accepted the chair of geology at Geneva in 1852, and at Bern in 1853.

This brilliant coterie of men of science, in the prime of life and in the heat of investigation laying the foundations of more than one department of human knowledge, included two other names of equal fame, Arnold Guyot, and Leo Lesquereux, both of whom still live to illustrate and enlarge our science. While Agassiz, Desor and Vogt were at work in the mountains Guyot was at work on the plain; while they studied the movement of the glacier, he defined the limits of the ancient moraines. As for Lesquereux, his study of the peat bogs of Switzerland, and then

of all northern Europe, led naturally to those broad generalizations respecting the coal-beds of all ages which have given him an immortal fame.

In 1847 Agassiz settled in the United States and commenced his career at Cambridge, Mass., after having opened the eyes of the British geologists to the glacial phenomena of great Britain. He soon drew after him to America Desor, Guyot, and Lesquereux.

Desor, before going to America, had published his own "Geological Alpine Journeys," and had traveled through Norway and Sweden in order to compare the moraine phenomena of Scandinavia with those of Switzerland.

In the winter of 1847–8 I found Agassiz and Desor at work together in a zoological laboratory in East Boston, watching a multitude of living creatures which they had obtained from the neighboring shore and kept in plates and bowls full of sea water. When Agassiz moved to his professorial residence in Cambridge Desor insisted upon remaining in this laboratory at East Boston. He soon became one of the lions of Boston society, but attached himself with the ardor of warm friendship to Edward Cabot, Theodore Parker and Josiah D. Whitney, who remained ever afterwards his devoted friends. He became intimate also with Asa Gray and Henry D. Rogers. It is needless to say that the circle of his habitual personal intercourse included such men as Emerson, Longfellow, Dr. Howe, and James Freeman Clarke.

The story of the separation of Agassiz and Desor which produced so great a sensation in the brilliant society of Boston men of letters and science will never be told, and need not be. In fact, however, the closest intimacy of years was sundered in a few weeks and the two never met again. Agassiz pursued thenceforth an independent career; became the idol of the western world; connected himself closely with Pierce and Bache and Gould; founded a school of natural history research; erected a vast museum; trained a considerable number of scholars to be the men of science of the present generation, and in fact not only gave Harvard College a new destiny, but inspired the entire population of the United States with a zeal for discovery in every branch of human knowledge which continues to burn and illuminate the world.

Desor at first turned to the study of the osars of the coast, and spent a summer with Davis in the study of the tidal gravel banks, always with an eye to glacial action.

He then joined Forster and Whitney in the survey of Lake Superior, under a commission from the United States Government; his special task was to study the alluvions and their fauna.*

In 1850 and 1851 he accepted proposals made to him by Henry D. Rogers to participate in the revision of the geological survey of Penn-

*His term, *Laurentian* for the recent deposits along the St. Lawrence and the Lakes has not been accepted by geologists, because of its subsequent application to the fundamental gneiss of the mountains of Canada. His views on the Northern Drift he published in the Amer. J. S., xiii, 93, 1852.

sylvania. As his task was to investigate the surface deposits, with a special regard to the possible existence and activity of a boreal glacier invading Pennsylvania, I saw much of him in my topographical studies for the construction of maps to show coal terraces, &c. and learned much from him about the movements of the surface sub-soil and local drift.

The study of glaciers led him to regard with critical eyes all phenomena of erosion, and his measurements of the retrocession of the falls of Niagara gave him a very different scale of geological time from that of Hall, Lyell and others. His diagramatic cross-section of the Via Mala, placed him partly in accord with and partly in opposition to the glacialists of the Ramsay school.

His glacial researches led him also necessarily to study rain and snow, the föhn or schnee-fresser and other winds; in a word he became a good meteorologist and made one of the band of early investigators, with Dové at their head, who established that branch of modern science. After his return to Europe he published papers on the "Climate of the United States and its effect on habits and manners."

At the close of 1851, or early in 1852, Desor was recalled to Neufchâtel by the serious illness of his brother, whom he nursed until his death, taking care of his property and becoming his heir.

Here a new career opened before him; he became a teacher. He was appointed to a chair in the Academy of Neufchâtel, made famous first by Agassiz, and now more famous by the lively, clear, eloquent, fresh teachings of Desor.

In the meantime he pursued his train of original research, and gradually devoted himself to the special branch of fossil echinoderms. His "Synopsis des Echinides" procured him a doctorate from the University of Bâle.

In 1856 his brother's death and the care of his inherited property induced him to resign his chair in the Academy; but while he tended his vineyard overhanging the lake, and farmed the old hunting-lodge of Combe Varin overlooking the Val de Travers, he pursued his researches in natural history, and continued his dredgings on the sites of the aboriginal lake-dwellers. He made unobtrusive use of his wealth in assisting others in their researches.

"He was himself," says one of his intimates, "not without some ambition. It flattered him to stand in relations to the first men of science and be known as their equal. The hospitality which he practised in the most liberal manner enlivened and preserved to him this intercourse which he so dearly loved. Every summer Desor's farm at Combe Varin, on the mountain top overlooking the railway station of Noiraigues on the road to Pontarlier, was a gathering point for notabilites not only of Switzerland but of all foreign countries, not only his friends but his acquaintances; and there reigned in this old hunting-lodge of the Depierres such a comfortable simplicity of entertainment and such perfect liberty of occupation that each guest felt himself entirely at home.

"On both sides of the level road which led from the brow of the mountain to the house stood rows of trees, each dedicated to some guest and marked with his name. More than a hundred names distinguished in politics and science may here be read, many of them now, alas, beneath a cross, to indicate their departure to a better world."

Four times I have myself shared his hospitality, and can testify to the charms of the place and of its master; and I esteem it as a kind of patent of nobility that my name stands among the rest. Here in 1859 Theodore Parker found a retreat, the summer before he died in Italy (1860), and his double-headed pine stood, at some distance off the road, on the open slope descending to the peat bogs which spread across the plateau between Combe Varin and the village of Les Ponts. Desor followed Parker to Italy, and was with him when he died. His attachment to him was based on their intercourse in Boston; and whatever spiritual theories Desor accepted were more or less formulated under the guiding influence of this powerful thinker and good and generous soul.

Desor was an active member of the Natural History Society of Neufchâtel, and published many short memoirs in its transactions. He leaves his remarkable museum of prehistoric antiquities to its care.

He was a constant attendant at the meetings of the Swiss Congress of Science, and would make long annual journeys to attend other similar national associations; especially of late years the annual meetings of the Anthropologists, as at Copenhagen and at Stockholm, where he was received with distinguished honor.

In fact Desor may be considered the chief of modern geological archæologists. After the first discovery of lake-dwellings in the winter of 1853–4 at Meilen on the shore of the lake of Zurich, and the commencement of Keller's great museum there, all the lakes of Switzerland were explored for similar discoveries. At least 200 villages were found by Desor and Clement in the lakes of Neufchâtel and Bienne; by Morlot and Troyon in the lake of Geneva, and by other seekers in other lakes. It was concluded that the Swiss lakes were unique in this respect, although Herodotus was quoted as authority for the existence of lake-dwellers in his day in a lake of Thrace. Desor however insisted upon the generality of the phenomenon, and at length made a rendezvous with Von Siebold, of Munich, to test the question in company with his own trained dredger. The immediate result was their great discovery that the palace of the Bavarian King was built on an island in the Sternsee around the edge of which could be seen the piles of the aboriginal lake-dwellers; and in the little museum of the palace they found a considerable number of needles, knives, chisels, &c. which had been dredged from the foundation of the palace. Upon this demonstration of the correctness of the large view which Desor alone had taken of the subject the geologists and antiquaries of Southern Germany and Austria set heartily to work and did not fail to find prehistoric relics in all the lakes of that part of Europe.

Desor subsequently (1864) joined Escher von der Linth the Swiss geol-

ogist, and Charles Martins the botanist of Montpellier, with a commission from the French government to explore the desert of Sahara, which they discovered to be of recent age by finding in its rocks recent shells. Here also Desor gratified his love of dolmens and menhirs, and greatly enlarged his prehistoric studies in that direction: but it was not until 1875 or thereabout that he became a zealous student of the mysterious cup and circle markings on the erratic blocks of Switzerland, and learned by a wide spread and laborious correspondence with his fellow-workers in all countries that they were not only to be seen on rocks from India to Scotland, but on the walls of the most ancient Christian churches of Northern Germany.

Desor was always recognized as an able geologist. His local work in the Jura, mostly carried on with the assistance of his poor friend and able palæontologist Gressly, showed ample ability to grapple with difficult structural problems, although he never freed himself from the prejudice in favor of split anticinals which the extraordinary section across the mouth of the Val de Travers would naturally inspire in any man who lived within sight of it. This prejudice, moreover, he shared with all the geologists of middle Europe. His astonishment and admiration for the unbroken arches of the Appalachian belt therefore, when at length his eyes were opened to their true character, was unbounded. But in spite of the impression thus made, he remained a consistent opponent of those views of cyclical erosion which were gradually forced upon American geologists, and were afterwards made popular in England by Beete Jukes in the course of the Irish survey.

Desor was the colleague of Bernard Studer, Peter Merian and Esher von der Linth in the commission of the geological survey of Switzerland. During my last visit to his own home in Neufchâtel, in 1880, he showed me an upper room in which the commission kept its archives and met for consultation. But the venerable Studer, the chief of the survey, has his home at the capital of the Confederation, Bern. One of the most remarkable pieces of geological investigation ever made was a section of a range of the Jura north of Neufchâtel, through which a long railroad tunnel was to be driven. Desor and Gressly projected the stratification as it should be found by the engineers. When the tunnel was finished the actual and hypothetical sections were almost absolutely identical. Each formation, almost each stratum, was struck at exactly the point indicated. It was a notable triumph of exact application of science to practical ends.

The political life of Desor is viewed differently, of course, by different classes of his friends. There is intense conservatism in Switzerland, and the overthrow of the aristocracy of the Canton of Neufchâtel by the democrats or radicals has never been forgotten nor forgiven.

As late as 1878, when I rode one day with Desor and Berthoud up the Val de Travers, they were making merry over some scurrilous attacks upon themselves in one of the newspapers; Desor pointed out to me a passage in which they were called derisively *the two small gods of Neufchâtel.*

In one of the obituary sketches of Desor (Basler Nachrichten), written perhaps by Desor's very steadfast friend Prof. Rütimeyer, I find the following paragraph :

"The burghers of Ponts honored Desor with the burger-right, and sent him, alternately with Neiraigue and Neufchâtel (as soon as the radicals got the majority in Neufchâtel), as member to the Grand Council, which once chose him its President. For many years Desor was a member also of the Ständerath, and of the Nationalrath (or Swiss Parliament), and one of its most distinguished members. Perhaps it would have been better for Desor the investigator had he devoted less of his time to politics ; nor did politics always bring sweet fruits to Desor the man. For ever since he fell away from his old comrades on the question of the repurchase of the Jura railway, and engaged himself personally in an endless newspaper war, which became ever more and more bitter and thankless, his health began to fail, and five years ago the symptoms appeared of that serious malady which led him inevitably to his grave."

The last three years Desor was sent by his physicians to spend the winters in Nice, where he became an active member of two scientific societies. He thus came to preside at the discovery of the fossil man of Carabacel which produced so great a sensation in the geological world. He directed also the researches made in the grotto of Peymanade, discovered by M. Bottin de St. Vallier. He managed in spite his sufferings to ascend considerable heights, and discovered satisfactory proof of the former existence of glaciers descending the southern slope to the shore of the Mediterranean. His letters to me on that subject display all the pleasure and zeal of a boy. His little maps and sections of the structure of the Ligurean coast are perfectly fresh.

Last February I went from Paris to Nice to see Desor for as I feared the last time, and found him extremely feeble and full of pain ; but I had so often seen him thus in former years that I dreaded no immediate danger. In our conversations he dwelt with lively interest on a plan which he was organizing to observe the temperature along the summits of the Pyrenees, and at the level of the plain. He went over again the old story of the Föhn or Alpine snow devouring south wind, in connection with the establishment of high winter sanataria for invalids in the Tyrol ; and also in connection with the observed winter temperature observed on the Puy de Dome relatively higher than on the plain at Clermont-Ferraud. He earnestly demanded data from the American stations to help discover the law, if it were one.

In a few days Desor was no more. The lamp that burned so brightly flickered a moment, and went out. All research was at an end. One of the sweetest, simplest, most honest, most affectionate, most robust and energetic, most independent natures that ever acquired fame abroad and inspired respect at home, suddenly ceased to suffer and ceased to think. Science had lost another star, Switzerland a sturdy champion of democratic liberty, and many of us a rare friend who cannot by any means be replaced.

Geological Notes. By E. W. Claypole.

(*Read before the American Philosophical Society, October 20th, 1882.*)

A. *On an Error in Identifying Two Distinct Beds of Iron Ore in Report* G *of the Geological Survey of Bradford County.*

In Report **G**, *Bradford and Tioga Counties*, and on page 36, occurs the following passage :

"6. In Leroy township, about a mile and a half west of Leroy, in the main road, near the house of J. Wilcox, we found a bed of iron ore which appeared to be three or four feet thick, and of very good quality. See the following partial analysis by Mr. McCreath :

Iron	29.5
Sulphur	trace
Phosphorus	.204
Insol. residue	49.27

"7. The *same* bed is exposed at Leroy village, in Gulf brook, where it is nearly four feet thick and of good quality. A partial analysis of this ore by Mr. McCreath resulted as follows, though it can hardly be a fair test, for the average percentage of iron must be greater :

Iron	20.7
Sulphur	trace
Phosphorus	.185
Lime	8.71
Magnesia	1.3
Insoluble residue	46.655 "

In reference to this passage I was informed during a recent visit in Bradford county by Mr. A. T. Lilley, of Leroy, that he considered it entirely erroneous, and that these beds of ore so far from being one were separated by a very considerable thickness of rock. The arguments which he adduced appeared to me quite satisfactory, and we went out to examine the ground.

Antecedently, if the two samples of ore were fairly taken, the analyses induce suspicion : they differ so largely from each other ; the quantity of iron is half as large again in the former as it is in the latter. It seems improbable that a bed of ore should vary so much in so short a distance.

The plan of this part of the valley given in Fig. 1, page 535, will make this line of argument intelligible.

The lowest bed of iron ore occurs in the Gulf brook in connection with

a mass of red sandstones, forming what are called the Mansfield Red beds. These beds, with a solid sandstone, continue westward and may be easily traced. The sandstone forms the buttress of the hill, and the Mansfield Red beds form a terrace higher up the slope. The direction of the strike of these beds is about N. E. by E. and S. W. by W.; but the flattening of the dip curves the outcrop line and throws the basset edge farther and farther from the road. In addition, higher beds continually pass across the road from south to north as one goes westward, the azimuth of the latter being slightly nearer the meridian than that of the former.

With the aid of Mr. Lilley, I traced the sandstone for about five hundred yards to the west from the mouth of the Gulf brook where the strata are vertical and found it gradually flattening down to a dip of about 45°. Leaving this bed I went across the outcrop of the strata southward, coming, of course, on newer and newer beds at every step. At the distance of about three-quarters of a mile from Leroy is a strong exposure of a hard red sandstone in thin beds covered with peculiar fucoidal marks. It forms a low ridge in the valley and crosses the road at a short distance farther on. The strike of this bed agrees with that of the others above mentioned, and the whole district is quite undisturbed by any dislocation. Following it for some distance, I left it and crossing the strike again to the southward, found a bed of green shale quite in the bottom of the valley, and immediately upon it a second bed of iron ore, very much like that at Gulf brook. It crops out in the road a little farther west, as mentioned in the extract from the volume **G**, given at the head of this note.

Beyond this bed of iron ore, which can be traced north of the road up the hill lie the highest beds of the Chemung group—the *Grammysia elliptica* bed, the *Productella bed*, and the Cap-rock—the last a thin shale full of crushed and unrecognizable fossils. Each bed is separated from the next by a considerable thickness of unfossiliferous shale.

It is therefore beyond a doubt that these two outcrops of ore mentioned in the extract from **G** given above, are not parts of the same bed, but belong to two different beds separated from one another by an interval of several, perhaps 250, feet.

If any further proof of this conclusion is desired it may be found near Franklindale. Reference to the map will show that the road forks about a mile west of the village.* The two branches again meet at the distance of half a mile east from the fork. By walking from the latter point along the south road the order of succession, from the Mansfield Red beds upwards, may be distinctly seen. In particular, the two seams of iron ore may be readily detected by the red ground and the red road formed by their destruction.

* The site of the village is wrongly given in the map in Report **G**. It should be where the four roads meet, about a mile east of the spot where it is marked. The two roads also should be drawn meeting each other again, as above mentioned.

B. *Note on the occurrence of Holoptychius, about 500 feet below the recognized top of the Chemung Group, in Bradford County.*

The base of the Castkill group has been assumed on palæontological grounds at the lowest stratum in which the remains of the great Ganoid fish *Holoptychius Americanus* have been found. Lithologically and stratigraphically this dividing horizon has been placed where the green fossiliferous shales of the Chemung are supplanted by red shales and sandstones, mostly without fossils. Sometimes these two principles of division give coincident, sometimes discordant, results. Often the fossil remains cannot be found, and almost as often the line between red and green material cannot be firmly drawn.

In Bradford county, however, these difficulties do not occur. The green rocks give place almost suddenly to the red ones, and the line between Chemung and Catskill is easily drawn on stratigraphical evidence. The red Catskill rocks also in many places abound in remains of fish near if not at their base, consequently the two lines of evidence converge to almost coincident results. The occurrence therefore of a well marked and unmistakable scale of *Holoptychius Americanus* considerably below the dividing plane is a fact worthy of some notice.

The scale in question is on the surface of a slab of green sandstone and was quarried out of the solid rock by Mr. Lilley, of Leroy, when getting stone for the foundation of a barn. Although I am unable at present to determine exactly the position of the sandstone, yet from the fact that it lies at a very small distance above the Mansfield Red bed with iron ore, it must be not far from four hundred feet below the base of the Catskill group, as recognized in this county.

In further proof of the occurrence of the above-named fossil in this horizon, I may add that while engaged with Mr. Lilley, in examining the evidence for the presence of the Catskill, north of Franklindale, Mr. L. picked up a loose slab of *green sandstone* showing on its surface three large scales of *Holoptychius*. The point where it was discovered is very near the horizon of the specimen first mentioned, the bed rock is very near the surface, little or no drift material is present, the slab is not rounded, and the Catskill rocks are on the other side of the valley of Towanda creek.

All this evidence concentrated, leads me to believe that this second specimen is of Chemung age and comes from the same horizon as the first.

C. *On a Mass of Catskill Rocks supposed to exist on the North Bank of Towanda Creek, near Franklin.*

Reference to the geological map of Bradford county will show a patch colored to represent the Catskill on the north bank of Towanda creek, in Franklin township. It measures about four miles in length by one in its

greatest breadth, and is apparently intended to represent a cap of that formation overlying the Chemung of the same township.

The existence of this cap of Catskill, or at least of a great part of it, is beset with numerous difficulties to one who is familiar with the ground, and during my recent visit in Bradford county I became strongly suspicious of the accuracy of the map. The following consideration was very weighty in this direction.

The Chemung rocks all along the north bank of Towanda creek dip to the south at angles varying from 90° to 15°. At Leroy, the former occurs, and east and west of Leroy the dip flattens down, but not regularly to the latter figure. The dip also flattens down as one recedes from the road and goes northward, but very gradually, so that at Leroy it does not disappear, and render the strata horizontal in less than a mile.

With this inclination of the beds and with the highest beds of the Chemung far out in the valley, probably in the west end of it on the south side of the Towanda creek, it seemed quite impossible that any such mass of the Catskill could occur capping them so near the road upon the north bank. The generalized section along the valley is given in Fig. 2, page 535.

When it is recollected that the total thickness of Chemung rocks between the top of the group at *a*, and the horizontal exposure at *b*, must be at least 1500 feet, and is probably more, the difficulty of realizing a cap of Catskill on the top of a hill only 200 or 300 feet high becomes obvious.

Aside, however, from all antecedent and theoretical considerations, it was desirable to obtain the evidence of actual observation, in order to ascertain the truth, and also, if possible, to detect the cause of the mistake, if mistake had been made. On the morning, therefore, of leaving Leroy, I obtained the assistance of Mr. A. T. Lilley, a gentleman well acquainted with the district and with its geology, and set out to investigate the ground.

Leaving Leroy by the Towanda road we first established the fact that lower and lower beds of the Chemung come continually out of the hill-side and point out into the valley for several miles, throwing the Catskill farther and farther to the southward, and giving a constantly thickening mass of Chemung to be placed on the hill-top, before the summit of that group could be reached. Turning to the northward up a road about one mile east of West Franklin, we followed it for nearly half a mile, until we attained an altitude of about 150 feet or more above the valley. The whole country on both sides of the road was deeply covered with drift, and no bed-rock whatever was visible anywhere. Nor was a scrap of the red Catskill sandstone to be found lying loose on the ground. Not only is it perfectly certain that no Catskill exists in place along this road (which follows a small run), but it is equally certain that many hundred feet of Chemung rocks are missing, and must be added to the top of the hill before the base of the Catskill can be reached. Yet this road on the map is drawn

crossing a broad belt of Catskill at less than half a mile from the valley turnpike. This Catskill cap does not, therefore, extend so far west as the road in question marked xx on Fig. 3, page 535.

Continuing our search we reached the point *a*, where the old and new roads meet and, taking the former or northern one, we crossed to the point marked with a cross. Here is a bold exposure of the Mansfield Red sandstones standing with a dip of about 40° S. E. by S. This point is almost exactly on the place where, according to the above-quoted map, the edge of the cap of Catskill should lie. It is unnecessary to say that no such material is there present. Not only are all signs of Catskill absent, but the whole thickness of the Chemung above the Mansfield red beds must be put on before its presence is possible. Time at our command did not allow us to go back into the county through the woods to determine at what distance this high dip disappears and the Chemung beds flatten down to a level, but it is perfectly obvious that even if any Catskill at all is here present it must be of small dimensions, and must lie much further north than it is represented on the map. With a dip of 40° at the point and about 500 feet of Chemung rocks missing, the existence of any such Catskill cap is almost a physical impossibility.

I may add that the evidence, so far as the short time at my command allowed me to examine it on the spot, is strongly against the existence of any Catskill west or north of Franklindale.

It appeared certain that the wreckage of the Mansfield Red beds, which is strewn over the hill-side along this part of the road, had been mistaken for fragments of Catskill, the source of which was supposed to exist higher up the slope. To account for the extension of the color so far to the westward is less easy, because, as mentioned above, not a fragment can be found upon the road marked with a double cross and lying east of West Franklin.

D.—*On two small patches of Catskill represented near Leroy, on the map in Report* **G**, *of the 2d Geological Survey of Penna.*

In connection with what has been written above, I may remark that not a scrap of evidence can be found in favor of the existence of either of the two round patches of Catskill rock represented on the map, one at Leroy and the other about one mile to the westward. The place in which the former is marked is on Upper Chemung beds, of about the horizon of the Mansfield Reds (which may have led to the error), and STANDING VERY NEARLY VERTICAL. The place of the other is near or at where the red sandstone with fucoids (mentioned in an accompanying note), which lies between the Mansfield Red beds and the *Grammysia elliptica* bed, crosses the valley road. Hence, perhaps, this mistake. The beds here are undoubtedly Chemung, and more than 100 feet below the summit of the group.

If this confusion was the real cause of the error it is the more surprising

because the iron ore bed which overlies the red fucoidal bed has been (as shown in the note above alluded to) confounded with another, occurring several hundred feet lower down in the series. If the presence of Catskill rocks is quite impossible with 100 feet of the Chemung missing, it would be much farther from possible if 400 or 500 feet were missing, as supposed in the report on Bradford and Tioga counties, p. 36.

E.—*On the Equivalent of the Schoharie Grit of New York in Middle Pennsylvania.*

The evidence of a single species, however "characteristic" it may be of a stratum or group of strata in one place in favor of identifying that stratum or group with another at any considerable distance, must always be of little weight unless strongly corroborated by collateral evidence. Even a single species, however, may be allowed to possess considerable value, *if thus corroborated.* From this point of view the following note may possess interest:

The *Cauda-Galli or Schoharie* grits of New York overlie the Oriskany sandstone. Of the former, Prof. Hall wrote in 1867 (Pal. of N. Y., Vol. 4, p. 1):

"The *Cauda-Galli* grit is almost a non-fossiliferous rock; a few fragments of plant-like fossils and the peculiar surface-markings of the slaty laminæ from which its name is derived, being the only objects resembling organic bodies which have fallen under my observation. A single specimen of *Platyceras*, similar to *P. tortuosum* of the Oriskany sandstone, has been found in this rock, * * * * It passes by almost imperceptible gradations to the Schoharie grit, which is marked by the presence of numerous fossils. The upper beds of the *Cauda Galli* grit, and also the lower beds of the Schoharie grit preserve those peculiar markings which have been termed *Fucoides Cauda-Galli* (*Spirophyton Cauda-Galli*)."

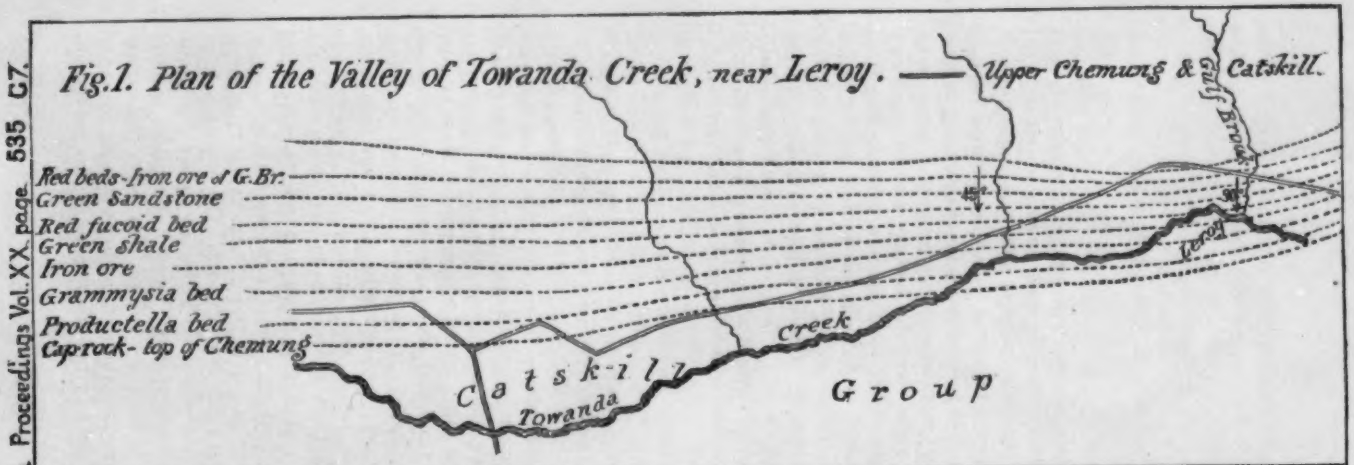
It thus appears that these two strata in New York form really one group within which no line of demarcation can be drawn. This group consists of unfossiliferous beds at the base, *Cauda-Galli* beds above them, and fossiliferous beds at the top.

The *Cauda-Galli* grit is, however, a stratum of very limited extent, considered lithologically. It does not occur in the western part of New York, but is well marked in the east and extends into New Jersey. It thickens toward the Hudson and reaches 50 or 60 feet in the Helderberg mountains.

The *Schoharie* grit is distributed over almost the same area as that of the *Cauda-Galli* grit, being specially well marked at Schoharie and in the Helderberg. Both strata doubtless owe their deposition to the same set of geological causes.

Neither of these *grits* occurs in Middle Pennsylvania in any spot which has fallen under my observation. The strata immediately overlying the Oriskany sandstone, in Perry and adjoining counties, consist of calcare-

Amer. Phil. Soc. Philadelphia. Proceedings Vol. XX. page 535 C7.



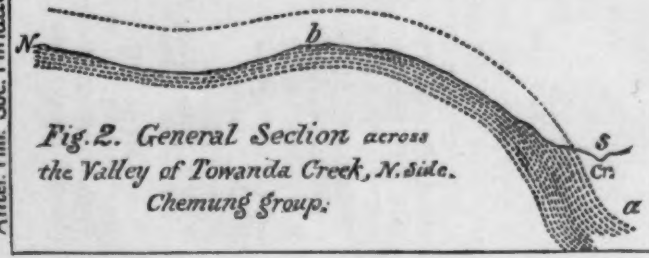


Fig.2. General Section across the Valley of Towanda Creek, N. side. Chemung group.

Fig.3. The supposed outline of a Catskill outlier in Franklin T.

ous shales, argillaceous limestones and iron ores. For the most part the lowest of these is an impure, earthy, hæmatite or a very ferruginous shale. Apparently these two materials belong to the same bed, but appear differently at different places. Near Bloomfield it is a hæmatitic shale of no value, and yielding thus far no fossils except on its upper margin, where an undescribed *Beyrichia* occurs in great numbers. A few miles south of Bloomfield, in Sandy Hollow, it is a tolerably pure red ochre, much of which has been dug and ground for paint, but apparently the work has not yielded sufficient profit to lead to its continuance. Here also I have found no fossils, but have reason to think that some might be obtained if the exposure were larger. This ochre lies close against the Oriskany sandstone, here nearly vertical. At a short distance further south the same bed again yields red ochre, which has been dug out close to the Oriskany sandstone. The best layers for this purpose are the lowest, and these have thus far yielded me no fossils. But about ten feet higher up, where the beds are less ferruginous, I have met with abundance of specimens of *Atrypa impressa* Hall. They are well marked and in a good state of preservation, being little altered by compression. They also occur solely as internal casts.

Regarding this species Prof. Hall says (Pal. of N. Y., Vol. 4, p. 316): "This form of Atrypa occurs in the Schoharie grit. It is not known to me in any other geological formation." Also (p. 315), "The casts of the interior are more abundant than any other condition of the fossil in the Schoharie grit."

From the above facts the inference seems warranted that these two grits of Eastern New York or some parts of them are represented by the ferruginous shales above mentioned. The sandstones indicate a shore line for the time being extending, during the whole or part of the period, from Eastern New York through Northwestern New Jersey into Eastern Pennsylvania. But west of this there is no evidence of anything but open sea for a long distance, and the finer sediments accord with the conclusion. The same species, *Atrypa impressa*, which lived near the shore or was washed ashore when dead and was buried in the sandstone in New York, sank in Middle Pennsylvania into soft oozy shale and was there preserved.

What the conditions were which produced the deposition of marine iron ores and ochres it is impossible at present to say. We are too ignorant of the processes of marine metallic sedimentation to do more than guess at them—a useless expenditure of time and thought.

Note on the progress of the Second Geological Survey of Pennsylvania. By J. P. Lesley.

(*Read before the American Philosophical Society, Jan. 19, 1883.*)

The progress of the Geological Survey of this State, which interests so many of my fellow-members, both in America and in foreign countries, deserves some record on the minutes of this Society, the mother society of our country, and in former times the natural rendezvous of American physical and mechanical science.

I venture then to offer to the Society the following short account of the ground already covered by the survey, as exhibited by its publications since 1875, county by county, in alphabetical order; with occasional notes respecting those counties in which further field work must be done before reports upon them can be made ready for the press.

It is needless to say, that the already collected data withheld as yet from publication for this purpose must be added to express the sum total of actual work done in the State.

Adams County. Surveyed in 1874 and 1875 by P. Frazer. See Report **C** on Adams and York (1876), and Report **CC** on Adams, York, Cumberland and Franklin (1877). *Note.*—Instrumental lines were run in both counties. The special topographical survey of the the South mountains in Franklin and Adams, commenced in 1876, was continued through 1877, 1878, 1879, 1880, northwards to Pinegrove furnace. In 1881 and 1882 this survey was carried forward in Cumberland and York counties towards Mount Holly Springs; and in 1883 it will be nearly or quite completed, to the end of the mountain range at Dillsburg. Four sheets have been printed, but will not be published until the remaining sheets of the South Mountain map are also printed. The whole will then be published in atlas form with a report, and in rolls for the use of surveyors.

Allegheny. Surveyed in 1875 and 1876 by J. J. Stevenson and I. C. White. See Report **K** on Greene, Washington and South-west Allegheny counties (1876); Report **KK** on Fayette, Westmoreland and eastern Allegheny (1877); Report **Q** on Beaver and N. W. Allegheny (1877).

Armstrong. Surveyed in 1879 by W. G. Platt. Report **H 5** (1880).

Beaver. Surveyed in 1876 by I. C. White. See Report **Q** (1877).

Bedford. Surveyed in 1881 by J. J. Stevenson. Report **T 2** (1882).

Berks. Surveyed in 1880 by R. H. Sanders. A geological map of the limits of the formations and the dip and strike of all exposed rocks in the valley is prepared, but not yet published. The sheets of the great topographical survey of the limestone belt and mountains of Lehigh and

Northampton (commenced in 1875, and completed in the spring of 1882), includes that part of Berks county lying east of the Schuylkill, with the hills west of Reading (by E. V. D'Invilliers). The sheets of this map are all printed, and will be published shortly in the Atlas to Report **D 3** (1883). The report on Berks county will be published after further work has been done in the county.

Blair. Surveyed in 1877 by F. Platt. See Report with Atlas **T** (1881). The topographical map of Morrison's Cove, Canoe valley and Sinking valley, with the Frankstown and Hollidaysburg region, reaching to the summit of the Allegheny mountain at Galitzen, was commenced by R. H. Sanders in 1875 and completed in 1877. See the Atlas to Report **T.** *Note.*—The delay in publishing this report was caused by the necessity which arose of detailing the assistant geologist for work in various other counties, which required immediate attention in view of the publication of their reports.

Bradford. Surveyed in 1874 by A. Sherwood. See Report on Bradford and Tioga counties, **G** (1878). *Note.*—The delay in publishing was caused by the fact that Mr. Sherwood was ordered to confine his attention to the rocks below the coal. In 1877 Mr. F. Platt reported on the coal basins, and Report **G** was then published. Subsequent work by I. C. White and E. W. Claypole has discovered such considerable errors in the survey of 1874 that a revision of the whole eastern and middle parts of the county, north of Towanda creek, should be made.

Bucks. The southern belt of the county was surveyed in 1879 and 1880 by C. E. Hall. See Report on Philadelphia county and the southern parts of Montgomery and Bucks, **C 6** (1881). This report gives a detailed description of all the rocks of the county south of the red shale country. The northern edge of the county has been included in the Atlas sheets of the topographical map of the South mountains (Reading and Easton range) about to be published with Report **D 3** on Northampton county (1883). The largest part of Bucks county has not yet been surveyed.

Butler. *Southern half* surveyed in 1876 by I. C. White. See Report on Beaver, and parts of Allegheny and Butler counties, **Q** (1877). *Northern half* surveyed in 1878 by H. M. Chance. See Report on Northern Butler, **V** (1878).

Cambria. Surveyed in 1875, by F. and W. G. Platt. See Report on Cambria and Somerset District, Part 1, Cambria, **H 2** (1879).

Cameron. Surveyed in 1878, 1879 by C. A. Ashburner and A. W. Sheafer. The report on Cameron, Elk and Forest was partly printed in 1881; but the publication was stopped by the transfer of the geologists to the Anthracite region, for organizing that survey. In 1883 there will be a revision of the work done in these three counties, and the Report **R 2** will then be published.

Carbon. The coal basin from Mauch Chunk to Tamaqua has been surveyed, and the sheets of maps and sections published to accompany Mr. Ashburner's first Anthracite report, **AA,** which will go to press in a few weeks. The survey of the Eastern Middle coal-field, commenced at Hazleton in 1881, has been continued uninterruptedly, and the sheets of the northern basins will be ready for press in 1883. The Beaver Meadow basin sheets will then be prepared. *Note.*—The geology of the Lehigh river below Mauch Chunk is described in the Report on Pike and Monroe counties, **G 6** (1882). The report on Carbon county requires further field work before it can be written.

Centre. Surveyed partially in 1880 and 1881 by F. Platt and W. G. Platt. Survey stopped by the resignation of both assistants. Mines revisited and sampled for analysis in 1882 by A. S. McCreath. Survey to be completed in 1883 for Report **T 3.**

Chester. Surveyed in 1879 and 1880 by P. Frazer. Southern townships re-surveyed in 1882 by C. E. Hall. See Report **C 4** just ready to issue from the press. *Note.*—The delay in publication was occasioned by the resignation of Mr. Frazer and his residence in Europe.

Clarion. Surveyed in 1879 by H. M. Chance. Report **VV** (1880).

Clearfield. Surveyed in 1874 by F. Platt. See Report on the Clearfield and Jefferson District, **H** (1875). *Note.*—This report was based on the work of an inexperienced party at the commencement of the survey, and before the recent important developments of the coal-fields of Clearfield. A resurvey of the county has been repeatedly ordered by the Board of Commissioners, and several attempts have been made to obey the order; but the occupations of the Geological Assistants in the various districts of the State up to the winter of 1881 and 1882 prevented it. The delay in passing the last annual appropriation bill cost the survey the loss of the geologists who were successively detailed to make this revision, and there were no others to take their place. The revision will probably be made in 1883, and a new report be published.

Clinton. Surveyed in 1879 by H. M. Chance. See Report **G 4** (1880).

Columbia. Surveyed in 1882 by I. C. White. Report now in preparation, to be published in 1883. For the coal, see *Schuylkill* county.

Crawford. Surveyed in 1879 by I. C. White. See Report on Erie and Crawford, **Q 4** (1881).

Cumberland. Surveyed in 1878 by R. H. Sanders. County map exhibiting all exposed outcrops and mines prepared. No report yet written. All mines visited in 1880, and ores personally sampled and analyzed by Mr. McCreath. See Report **M 3** (1881). *Note.*—The peculiar character of

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the Great valley required that the same kind of survey should be made of Franklin, Cumberland, Dauphin, Lebanon and Berks together. Each county has been similarly mapped by R. H. Sanders. All will be published at the same time. Mountain survey to be finished in 1883.

Dauphin. Surveyed in 1879–'80 by R. H. Sanders. County map exhibiting all exposed outcrops, mines and limits of formations, prepared. Mines personally visited and ores sampled in 1882 by A. S. McCreath. Report delayed for general revision in 1883, in connection with Lebanon and Berks. For the coal, see *Schuylkill* county.

Delaware. Surveyed in 1881 by C. E. Hall. See Report **C 5** (1883), to be published in the same volume with the report on Chester county, **C 4.** *Note.*—This publication has been delayed by the impossibility of preparing the illustrations for the report until after the report on Chester, with its illustrations, had been provided. Delaware was formerly a part of Chester, and its geology is dependent on that of Chester. The combined report has been printed and its maps, &c., are mostly printed. The whole will be published this winter.

Elk. Surveyed in 1877 and 1878 by C. A. Ashburner and A. W. Sheafer. The maps and sections to accompany the report were printed in 1880. The publication of the report was stopped by the transfer of the geologist to the Anthracite region. The important developments made in the coal basins of this county since 1878 make it desirable to revise this survey. This will be done in 1883, after which the Report **R 2** will be published.

Erie. Surveyed in 1879 by I. C. White. See Report on Erie and Crawford, **Q 4** (1880).

Fayette. The western part surveyed in 1876, the eastern part in 1877, by J. J. Stevenson. See Report on Fayette and Westmoreland counties, **K 2** (1877), and Report on the Ligonier valley, **K 3** (1878). *Note.*—Report **L** (1876) gives the special survey of the Coke region.

Forest. Surveyed in 1879 by C. A. Ashburner and A. W. Sheafer. The report on the coal areas and general geology will be published in 1883 in conjunction with the report (**R 2**) on Elk and Cameron counties. The wells of Forest county are described in the Report on Warren county, **I 4,** by J. F. Carll, now just ready for binding, and which will be published in February.

Franklin. Surveyed in 1879 by R. H. Sanders. County map exhibiting all exposed outcrops and mines prepared. Mines revisited in 1880, and ores sampled personally by A. S. McCreath, and analyzed. See Report **M 3** (1881). Northern part surveyed in 1877 by J. H. Dewees.

Instrumental line run in 1878 by C. W. Ames. South mountains instrumental surveyed in 1880–'81 by A. E. Lehman. Report delayed by the office work on instrumental surveys.

Fulton. Surveyed in 1882 by J. J. Stevenson. See Report on Bedford and Fulton, **T 2** (1882).

Greene. Surveyed in 1875 by J. J. Stevenson. See Report on Greene and Washington, **K** (1876). A special Report on the Collieries and Coal of the Monongahela valley will be made by J. S. Wall.

Huntingdon. Surveyed partially in 1874–'75 by J. H. Dewees, C. A. Ashburner and C. E. Billin. See Report on the Juniata District, **F** (1878). *Note.*—That part of this report relating to the Broad Top coal basin was reserved for future publication. The eastern end of the county was surveyed by Mr. Billin in connection with his topographical survey of the Seven mountains, some maps and sections of which have been printed. Mr. Billin's resignation early in 1879 stopped both the work and the report; but he is now completing the report for publication. Much work remains to be done in various parts of the county before a complete county report can be prepared.

Indiana. Surveyed in 1877 by W. G. Platt. See Report **H 4** (1878).

Jefferson. Surveyed in 1880 by W. G. Platt. See Report **H 6** (1881). *Note.*—The first partial survey of Jefferson in 1874–'75, was published in Mr. F. Platt's report of Clearfield and Jefferson, **H** (1875).

Juniata. Surveyed in 1876 by J. H. Dewees. *Note.*—This voluminous report required rewriting, for which there has been no sufficient opportunity. Maps of Juniata and Perry have been prepared. A resurvey of both counties by E. W. Claypole is in progress. Reports on both counties to be printed in 1883.

Lackawanna. Parts lying outside the coal, surveyed in 1882 by I. C. White. See forthcoming Report **G 7** (1883). Coal basin survey by C. A. Ashburner and corps, commenced in 1881 and continued through 1882 and onwards, proceeds from west to east, and will not reach Lackawanna until 1884. See Luzerne. *Note.*—For the east end, see Report **G 5**, I. C. White (1881).

Lancaster. Surveyed in 1877 by P. Frazer. See Report **C 3** (1880). *Note.*—Elaborate and difficult illustrations caused the delay.

Lawrence. Surveyed 1877 by I. C. White. Report **Q 2** (1878).

Lebanon. Surveyed in 1880–'81 by R. H. Sanders. County map prepared, exhibiting all local outcrops, limits of formations, mines, &c. Report delayed for work to be done in 1883.

Lehigh. Surveyed in 1874–'75 by F. Prime. See Reports on the Iron Ore district, **D** (1875), **D 2** (1878), with atlas. *Note.*—The delay of the last report was occasioned by the fact that the instrumental survey of the limestone valley belt and of the mountains continued from year to year, and was not finished until 1882. The survey of the slate belt in 1881 by R. H. Sanders will appear in the Report on Lehigh and Northampton **D 3,** with atlas, mostly printed and to be published shortly.

Luzerne. Parts lying outside the coal, surveyed in 1882 by I. C. White. See forthcoming Report **G 7** (1883). Coal basin survey by C. A. Ashburner and corps, commenced in 1881 and continued through 1882 and onwards. Western sheets ready for printing. Middle sheets in preparation. A special report will accompany the sheets of each division.

Lycoming. Surveyed in 1877 by A. Sherwood, and again in 1878–'79 by F. Platt. See Report on Lycoming and Sullivan, **G 2** (1880). *Note.*—The delay was caused by imperfections in the first survey, which could not be corrected sufficiently early in 1878.

McKean. Surveyed in 1876, 1877 and 1878, by C. A. Ashburner and A. W. Sheafer. See Report **R** (1880). *Note.*—The length of this survey was due to the amount of instrumental work needful for its study; and the delay of its publication, to the careful preparation of its atlas of illustrations. The geology of Cameron, Elk and Forest was studied preliminarily in connection with that of McKean; and afterwards separately and in detail.

Mercer. Surveyed in 1878 by I. C. White. See Report **Q 3** (1879).

Mifflin. Surveyed by J. H. Dewees, C. A. Ashburner and C. E. Billin in 1874–'75–'76. See Report on Juniata District, **F** (1878). *Note.*—Kishicoquillis valley not surveyed.

Monroe. Surveyed in 1881 by I. C. White. See Report on Pike and Monroe, **G 6** (1882).

Montgomery. Southern part surveyed in 1879, 1880 by C. E. Hall. See Report on Philadelphia belt, **C 6** (1881). The rest of the county to be surveyed in 1883. (See *Bucks.*)

Montour. Surveyed in 1882 by I. C. White. To be published in Report **G 7** in 1883.

Northampton. Surveyed in 1876 by F. Prime. Slate belt surveyed in 1881 by R. H. Sanders. Mountain survey finished in 1881. Mountains revised in 1882 by C. E. Hall. See Report **D 3** mostly printed and soon to be issued, with Atlas. See *Lehigh.*

Northumberland. Surveyed partially in 1877 by C. E. Billin; again in 1882 by I. C. White. To be published in Report **G 7** in 1883. For the coal see *Schuylkill* county.

Perry. Surveyed in 1877 by J. H. Dewees. Surveyed again in 1882 by E. W. Claypole. Report to be published in 1883.—*Note.* The delay in publishing the report of 1877 was occasioned by the necessity for completely rewriting it. See *Juniata*.

Philadelphia. Surveyed in 1879, 1880. See Report **C 6** (1881).

Pike. Surveyed in 1881 by I. C. White. See Report on Pike and Monroe, **G 6** (1882).

Potter. Surveyed in 1876 by A. Sherwood. Resurveyed in 1879 by F. Platt. See Report **G 3** (1880).

Schuylkill. Anthracite survey commenced in 1881 by C. A. Ashburner and corps, continued through 1882 and onwards. Eastern sheets of Western Middle coal-field now in press; western sheets in preparation. Special report on each division to accompany the sheets. In 1884 the survey of the Southern coal-field from Tamaqua westward will be commenced. See *Carbon* county.

Snyder. Surveyed in 1876, 1877 by J. H. Dewees. See Report on Juniata District, **F** (1878). Surveyed again in 1878 by C. E. Billin, for map. Further field work before a county report can be published.

Somerset. Surveyed in 1879 by G. W. Platt. Report **H 3** (1877).

Sullivan. Surveyed in 1877 by A. Sherwood, and again in 1878–'79 by F. Platt. See Report on Lycoming and Sullivan, **G 2** (1880). The Coal basins will be resurveyed as part of the Anthracite survey.

Susquehanna. Surveyed in 1880 by I. C. White. See Report on Susquehannah and Wayne, **G 5** (1881).

Tioga. Surveyed in 1874 by A. Sherwood, and in 1877 by F. Platt. See Report on Bradford and Tioga, **G** (1878). See Note on *Bradford*.

Union. Surveyed in 1878 by C. E. Billin for map. Requires much field work before report can be published.

Venango. Surveyed in 1874 and onwards by J. F. Carll. See Reports on the Oil regions **I** (1875), **I 2** (1877), **I 3** (1880) and **I 4** (1883 just being issued).

Warren. Surveyed in 1874 and onwards, especially in 1882, by J. F. Carll. See Report on Warren county, **I 4** (1883 just issuing from the press). *Note.*—The long delay in reporting upon this county was occasioned by the abundance of its fossils; the extreme difficulty of establishing the correct order of its rocks; and the continued oil discoveries.

Washington. Surveyed in 1875 by J. J. Stevenson and I. C. White. See Report on Greene and Washington, **K** (1876). A special Report on the colleries of the Monongahela valley will be made by J. S. Wall.

Wayne. Surveyed in 1880 by I. C. White. See Report on Susquehanna and Wayne, **G 5** (1881).

Westmoreland. Surveyed in 1876 and 1877 by J. J. Stevenson. See Report on Fayette and Westmoreland **K 2** (1877), and on the Ligonier valley **K 3** (1878). *Note.*—Report **L** (1876) gives an account of a special survey of the Connellsville Coke region.

Wyoming. Surveyed in 1876 by A. Sherwood. Resurveyed in 1882 by I. C. White. See Report **G 7,** to be published in 1883.

York. Surveyed in 1874, 1875 and 1876 by P. Frazer. See Reports on Adams and York, **C** (1876) and **C 2** (1877).

Of the above mentioned Reports, **AA, C 3, D 2, D 3, I 3, R** and **T,** are accompanied by octavo Atlases, containing maps and sections. The following Reports have been published:

Report **A** (1875). A history of geological surveying in Pennsylvania.

Report **A 2,** on Waste in mining Anthracite, by F. Platt (1881).

Report **AC** on the mining of Anthracite coal, by H. M. Chance, will be put to press this winter (1883).

Report **E,** on Azoic rocks, by T. S. Hunt (1878).

Report **J.** Special report on Petroleum, 1875.

Reports **B, B 2, M, M 2, M 3** are the successively published reports of chemical analyses made for the Survey by F. A. Genth, S. P. Sadtler, F. A. Genth, Jr., A. S. McCreath and J. M. Stinson.

Report **N.** (1878) contains the Levels of the State railroads, canals, roads, &c., collected in 1875, 1876, 1877 by C. Allen. Materials for **N 2** are largely collected.

Reports **O, O 2** contain the catalogue of specimens collected from 1874 to 1880. **O 3** has not yet been prepared.

Report **P** (and Atlas) figures and describes the coal plants, studied by L. Lesquereux, from 1874 to 1880.

Report **P 2** describes the Permian plants of Greene county and West Virginia, by Fontaine and White (1880).

Report **P 3** containing new species of coal plants by Leo Lesquereux and descriptions of articulates and mollusks, by C. E. Beecher, James Hall and E. W. Claypole, will be published in 1883.

Report **Z** on the glacial moraines and gravels by H. C. Lewis, is nearly ready for the press.

The small hand-book or traveling atlas of geologically colored county maps is two thirds prepared, and will be finished in 1883.

First Addition to the Fauna of the Puerco Eocene. By E. D. Cope.

(*Read before the American Philosophical Society, Jan. 5, 1883.*)

There are fifty-five species included in my synopsis of the vertebrata of the Puerco epoch*. Ten of these are reptilia, the remainder mammalia. In the present paper a number of interesting additions are made. The typical specimens are figured in the fourth volume of the U. S. Geological Survey of the Territories, now in press.

OPHIDIA.

HELAGRAS PRISCIFORMIS, gen. et sp. nov.

Char. gen. The generic characters are drawn from vertebræ only. These display a modified form of the zygosphen articulation, as follows: The roof of the zygantrum is deeply notched on each side of the median line so as to expose the superior lateral angles of the zygosphen. This separate median portion of the roof of the zygantrum forms a wedge-shaped body which may be called the *episphen*. It is surmounted by a tuberosity, which constitutes the entire neural spine. The latter is thus entirely different in form from that of other serpents. Articular extremities of centrum round, the ball looking somewhat upwards. Costal articulation 8-shaped, the surfaces convex and continuous. Hypapophyses none on the two vertebræ preserved. Zygapophyses prominent. Free diapophyses none.

This genus is readily distinguished by the presence, now first observed, of the *episphen* in addition to the zygosphen; and by the peculiar form of the neural spine. We have now several vertebral articulations originally discovered in American vertebrata. These are the *episphen* as above, the *hyposphen*, which characterizes the Opisthocœlous Dinosauria (*Sauropoda* Marsh), and the *Diadectidæ* of the Permian period; and the *zygantrapophysis*, which is present in the Diplocaulid family of Batrachia.

Char. specif. A section of the vertebra at the middle is pentagonal, the inferior side slightly convex downwards. The lateral angle is the section of the angular ridge which connects the zygapophyses The episphen has a shallow rounded groove on its infero-posterior side, which is bounded by a projecting angle on each side at its middle. The episphen does not project so far posteriorly as the postzygapophyses, and the degree of its prominence differs in different parts of the vertebral column. In one of the two vertebræ in my possession its prominence is small. The tuberosity on its summit is a truncate oval with the long diameter anteroposterior, and equaling two-fifths the length of the arch above. It is elevated above the rest of the median line, which is roof-like, with obtuse angle. The tubercular articular facet is entirely below the prezygapophyseal surface, but the free part of the prezygapophysis extends well in front of it. It is distinguished from the capitular surface by a very slight constriction. A slight ridge extends from the capitular articulation

* Paleontological Bulletin No. 35, Nov. 11th, 1882.

to the edge of the ball of the centrum. Below this the surface is slightly concave, and the middle line is gently convex. The latter terminates in an obtuse angled mark just in front of the edge of the ball. This edge is also slightly free from the ball. The capitular costal surfaces do not project inferiorly quite to the line of the inferior surface of the centrum.

Measurements of a Vertebra.	M.
Length of centrum (with ball)	.0070
Diameters of ball { vertical	.0035
Diameters of ball { transverse	.0040
Elevation of vertebra at episphen	.0085
" " middle	.0062
Width at prezygapophyses	.0120
" tubercular costal faces	.0105
" of zygantrum	.0058
Vertical diameter costal faces	.0040
Transverse diameter tubercular costal face	.0028

This snake was about the size of the black snake, *Bascanium constrictor*. It is an interesting species for two reasons. First, it is the oldest serpent known from North America. Second, in the imperfection of the zygantrum we observe an approximation to the ordinary reptilian type of vertebra, from which the ophidian type was no doubt derived. In the former there is no zygosphen or zygantrum.

Mammalia.

Triisodon levisianus, sp nov.

This creodont is represented by part of a right mandibular raums which contains the fourth premolar minus its principal cusp, and the first and second true molars, with the alveoli of the third. The ramus is deep, and probably belonged to an animal of about the size of the red fox. The molars have the structure most like that of the *T. heilprinianus*, especially anteriorly. The principal anterior cusps are united together for most of their elevation, while the anterior inner is much smaller and lower, and is situated between the middle and inner side of the anterior cusp. The heel is rather wide, and has a raised border. The external part of it is angular, and is somewhat within the vertical line of the base of the crown. The fourth premolar differs from that of the type the genus, *T. quivirensis*, in having two acute longitudinal tubercles situated close together on the heel.

The anterior masseteric ridge is very prominent. The masseteric fossa is strongly concave, but shallows gradually inferiorly. Its inferior border presents a low thickened ridge, which is recurved in front. This may be an individual character only. The inferior outline of the ramus is generally convex, and does not rise much below the masseteric fossa.

Measurements.	M.
Length of last four inferior molars	.0315
" true molars	.0230
Diameters of M. i. { anteroposterior	.0085
Diameters of M. i. { transverse	.0055
Length of P-m. iv. on base	.0090
Depth of ramus at M.i	.0200
Thickness " "	.0085

This *Trisodon* is not only materially smaller than the *T. heilprinianus*, but differs in the characters of the heel of the inferior molars. In that species the internal border is tubercular; in this one it is entire. The *T. conidens* and *T. quivirensis* differ in the arrangement of the anterior cusps.

Dedicated to my friend, Henry Carvill Lewis, professor of mineralogy and geology in the Academy of Natural Sciences, Philadelphia.

MIOCLÆNUS FEROX, sp. nov.

This new species is represented by three specimens. One of these includes various separate teeth and a considerable portion of the skeleton; a second includes loose teeth and a smaller number of bones of the skeleton; and the third consists of a part of a mandibular ramus, which contains the three true molars. These indicate the largest species of the genus yet known, the first individual above mentioned being about the size of a wolf.

The bones of the *Mioclænus ferox* enable me to refer the genus approximately to its proper position in the system. Although we do not possess the corresponding parts of the *Mioclænus turgidus*, the type of the genus, it is probable, if not certain, that they agree in generic characters. The agreement in dentition extends to all the principal technical points, though the specific differences are marked.

The skeleton is that of a creodont. The unequal phlanges are compressed claws, and the metapodial bones have protuberant condyles. The astragalus has a simple head with convex surface, and the trochlea is a shallow open groove.

The tubercular dentition refers this genus to the *Arctocyonidæ*.* With this family it is accordingly placed provisionally. It differs from the known fossil genera in the single tubercle of the internal part of the crown of the superior molars.

The species *M. brachystomus* and *M. etsagicus* of the Wasatch epoch must now be removed from this genus. I have shown that the former is an Artiodactyle. Now in technical points, the dentition of those species is identical with that of *Pantolestes* Cope, as well as with *Mioclænus*. Although the skeleton of the type of *Pantolestes, P. longicaudus* of the Bridger Beds, is yet unknown, it is safe to suppose that it does not differ from that of the *M. brachystomus*. I therefore refer the two species first mentioned to *Pantolestes*, and place that genus in the Artiodactyle sub-order.

* For the dentition of this family see Lemoine, Annales, Sc. Nat., 1878, July.

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Char. specif.—The canines are well developed, and have a robust root. The crown is rather slender and is very acute. It is rounded in front, but has an acute angle posteriorly. It is not grooved, and the enamel is smooth. The single-rooted first superior premolar is situated close to the canine, and behind it is a short diastema. I have the probable first true molar or fourth premolar. The external cusps are rather small, and are well separated from each other. The inner outline of the crown is rather broadly rounded. The internal tubercle is connected on wearing, with an anterior transverse crest which terminates near the inner base of the anterior external cusp in an intermediate tubercle. There is a posterior intermediate tubercle. There is a cingulum all round the crown excepting at the posterior intermediate tubercle. The second (? first) true molar is like the one just described, but has relatively greater antero-posterior width. In this tooth the cingulum extends all the way round the crown.

There are but two inferior molars of this individual preserved, the second and third true. The former of these has a parallelogrammic outline with rounded angles. There are two posterior and two anterior rather large tubercles; an anterior transverse ledge; and a narrow external and posterior cingulum, the latter running into the internal posterior tubercle. The latter has a circular section, and is much smaller than the external posterior, which has a wide crescentic section. Of the anterior tubercles the anterior is much the larger, judging from its worn base. The third true molar is triangular in outline. Its crown includes two anterior and an external median tubercle. The inner and posterior parts of the crown form a wide shelf, with the internal edge denticulate. A weak external cingulum.

Measurements of Teeth.		M.
Diameters base of crown of incisor	anteroposterior	.0045
	transverse	.004
Diameters base crown of canine	anteroposterior	.0130
	transverse	.0095
Diameters crown, superior M. i.	anteroposterior	.0095
	transverse	.0120
Diameters, M.? ii.	anteroposterior	.0110
	transverse	.0110
Diameters of inferior M. ii	anteroposterior	.0120
	transverse	.0105
Diameters of inferior M. iii.	anteroposterior	.0125
	transverse	.0090

The second individual includes part of the superior walls of the skull. The fragment displays a high sagittal crest, which is fissured in front so as to keep the temporal ridges apart to near its anterior apex. The brain surfaces show small, smooth, flat hemispheres, separated by a constriction from the wide and large olfactory lobes. The navicular bone shows three well defined distal facets, indicating probably five digits in the pes. The teeth of this specimen include a posterior superior molar, and an inferior

third or fourth premolar, with other teeth. The premolar is like that of a creodont. Its principal cusp is a simple cone. To this is added a short wide heel, whose superior surface is in two parts, a higher and a lower, divided by a median ridge. A low anterior basal lobe, and a weak external cingulum.

The third specimen belonged to an individual a little smaller than the other two. It includes the first inferior true molar, a tooth lost from the others. Its form is somewhat narrowed anteriorly, where it has two low, but well separated anterior inner tubercles, which form a V with the external anterior.

Specimen No. 1 is accompanied by fragments of vertebræ and limbs. The former are principally from the lumbar region, but fragments of the atlas remain. This vertebra is of moderate length, and the cotylus is somewhat oblique. The vertebrarterial canal is rather elongate, and its anterior groove-like continuation in front of the diapophysis is not deeply excavated. The lumbar vertebræ are remarkable in the characters of their zygapophyses. These display subcylindric surfaces of the posterior pair, which indicates that the anterior ones are involuted, as in the specialized Artiodactyles and Perissodactyles of the later geological ages. Such a structure does not exist among carnivora, nor to my knowledge among creodonta, nor in any mammals of the Lower Eocene. I do not find it in *Didelphys* nor *Phascolarctos*, but it exists in a moderately developed degree in *Sarcophilus*. The articular surface forms more than half of a cylinder, and its superior portion is bounded within by an anteroposterior open groove. The surface within this is not revolute, as in *Bos* and *Sus*, but the articular surface disappears, as in *Cervus*. Eight such postzygapophyses are preserved, all disconnected from their centra. Two of them are united together. There are two other separated zygapophyses of smaller size, which have but slightly convex surfaces. One is probably a prezygapophysis of a dorsal vertebra. No centrum is preserved.

Of the anterior limb there is a probable distal half of a radius. It is of peculiar form, and resembles that of *Sarcophilus ursinus* more than any other species accessible to me. One peculiarity consists in the outward look of its carpal surface, which makes an angle of about 45° with the long axis of the shaft. The obliquity in *S. ursinus* is less. The external border of the shaft in *M. ferox* is, however, straight, and terminates in a depressed tuberosity. Beyond this, the border extends obliquely outward to the carpal face, which it reaches at a right angle. The internal border of the shaft is gradually curved outwards to the external border of the carpal face. Its edge is obtuse, while the external one is more acute for a short distance, and rises to the anterior (superior) plane of the shaft. The carpal face is a spherically subtriangular with rounded angles. It displays two slightly distinguished facets, one of which is superior, and the other is larger and surrounds it, except on the superior side. The internal marginal projection, or "styloid process," is not so prominent as in *S. ursinus*, and is a roughened raised margin. Joining it on the inferior edge of

the carpal face is another rough projection of the margin. Immediately opposite this, on the superior edge of the carpal face, is a rough tuberosity, which encloses a small rough fossa, between itself and the styloid process. Internal to it is a shallow groove for an extensor tendon of the manus; then a low short ridge, and internal to that a wide shallow depression for other extensors. The carpal face differs greatly from those of *Sarcophilus* and *Didelphys* in having the inner portion wider than the outer, instead of the reverse, and in having no distinct styloid process. It indicates that the manus was turned outwards much more decidedly than in those genera.

Of carpal bones the only recognizable one is the unciform. Its proximal articular surface rises with a strong convexity entad, and descends to an edge ectad. The metacarpal surface is concave in anteroposterior section, forming a wide shallow groove, extending in the direction of the width of the foot. Its two metacarpal areas are not distinguished. The entire first and second metacarpals, with the heads of the third and fourth are preserved. They considerably resemble those of *Sarcophilus ursinus*. The distal articulations are injured in both, but both display a sharp trochlear keel posteriorly, which on the second extends nearly to the superior face of the articulation. The condyle is subround, and is constricted laterally, and at the base above. The second metacarpal is short and robust, shorter than in *Sarcophilus ursinus*. The first is also robust, but is relatively longer, as it is three-quarters the length of the second. Its head is expanded, especially posteriorly, and the large trapezial face is subtriangular, with round apex directed inwards as well as forward. The posterior face of the head is notched ectad to the middle. On the external side of the head there is a vertical facet with convex distal outline, for contact with the second metacarpal. The head of the latter is narrow, and is concave between the sides. The concavity is bounded posteriorly by a raised edge. The anterior part of the proximal facet is decurved. The shaft is deep proximally, but on the distal half is wider than deep. The lateral distal fossæ are remarkably deep and narrow, the condyle very much contracted. The head of the supposed third metacarpal is as wide as the second anteriorly, but narrows to the posterior third, and then contracts abruptly to a narrow apex. The supposed external side of the head is perfectly straight, and is continuous with the side of the shaft without interruption. The entad side displays no facet, but has a depression below the head which adapts itself very well to the head of the first metacarpal. In fact, if the metacarpals just named second and third, exchange places, so that second is placed third and third second, the metacarpal series fits far better. The fourth fits the so-called second much better than the so-called third. This may therefore be the true order, although that first used agrees better with the carpus of *Sarcophilus*. The head of the so-called third is slightly convex anteroposteriorly, and is oblique laterally, descending a little to the inner side. The fourth metacarpal is wider anteriorly than either the second or third. The inner edge is straight, while

the outer is concave, the head being narrower before than behind. It has a lateral facet on each side; the inner plane, the external concave in the vertical as well as in the anteroposterior direction. It thus approaches the form of a metatarsal, but is not so strongly excavated, nor is the head notched on either side. The unciform face is convex anteroposteriorly and plane transversely.

The *femur* is broken up so that I cannot restore it. The head of the *tibia* is gone, but a considerable part of the astragalar face is preserved. This is transverse to the long axis of the tibia. It is narrowed anteroposteriorly next the fibular facet. Malleolus lost. The shaft is robust, and does not expand distally for articulation with the astragalus. Three centimeters proximal to the distal end, the external side throws out a low, rough, ridge-like tuberosity. Above the middle the crest turns outwards, leaving the internal face convex. There is a broken patella, which has one facet much wider than the other.

The *astragalus* has the trochlear portion a little oblique. That is, the internal crest is a little lower than the external, and the inner face is a little sloping. The latter is impressed by a fossa above the posterior part of the sustentacular facet, which runs out on the neck. The trochlea has a shallow groove which is nearer the external than the internal crest, and which passes entirely round the posterior aspect to the plane of the inferior face of the astragalus. The groove for the flexor tendon is thus entirely enclosed, and issues on the inferior face at the posterior extremity of the groove which separates the sustentacular from the condylar facets. The external crest of the trochlea is less prominent posteriorly than the internal, thus reversing the relations of the superior part. The internal ridge becomes quite robust, but does not flatten out and project sub-horizontally as in *Oxyæna forcipata*. The fibular face is vertical; neither its anterior nor posterior angles are produced. The neck is somewhat contracted (the internal side is injured). The head is a transverse oval, strongly convex vertically, moderately so horizontally, and without flattening. A *mesocunëiform* (or possibly *ectocunëiform*) bone is wedge-shaped in horizontal section, without posterior tuberosity, and its anterior face is a slightly oblique square. The narrower facet is oblique in the transverse sense.

The *metatarsals* are represented, excepting the first and second. The only complete one is the fifth. The heads of the third and fourth are much like those of *Oxyæna forcipata*, and of about the same size. Their anterior width is equal, and in both the external side is more oblique than the internal. Both have a notch at the middle of the internal side, but they differ in that the third has an open notch on the external side which is wanting to the fourth. The lateral excavations of the external sides are deep and rather large, and thin out the anterior external edge. The lateral facets are correspondingly large on the fourth and fifth; on the third metatarsal it is small, and a mere decurvature of the proximal surface. That of the fourth is longer proximo-distally than transversely. That of the fifth is about as long as wide, and presents more anteriorly; or, to express it

more accurately, the shaft and head present more outwardly than those of the fourth. The proximal, or cuboid facet is narrow anteroposteriorly, and is curved, the external side being concave. On the external side just distal to this facet, the head of the bone expands into a large outward-looking tuberosity, which is separated from the posterior tuberosity by a strong notch. Between it and the head proper, on the anterior face, is a large fossa. The entire form is something like that of the proximal extremity of a femur with head, neck, great trochanter and trochanteric fossa. A somewhat similar form is seen in the corresponding bone of *Oxyæna forcipata*. The shaft of the fifth metatarsal, is one-fifth longer than that of the second metacarpal (? 3d) above described. Its direction is straight, but it is somewhat curved anteroposteriorly. Its section is subtriangular, the apex external. The condyle is narrowed and sub-globular above, and spreads laterally behind, the external expansion being wide and more oblique. The keel is prominent, and is only visible from above (in front) as an angle. The distal extremities of some other metatarsals differ in being flatter at the epicondyles, and concave between them on the posterior face. The condyles are more symmetrical, and are bounded above on the anterior face by a profound transverse groove. Several *phalanges* are preserved, including part of an unguis. They are all depressed, and with well marked articular surfaces, of which the distal are well grooved, and the proximal notched below. The lateral areas of insertion of the tendons of the flexors are well marked on the edges of the posterior faces. An ungual phalange is much compressed at the base. The basal table is well marked, and has a free lateral edge. The nutritive foramen enters above the posterior extremity of this edge. No trace of basal sheath.

Measurements of No. 1.	M.
Length of atlas at anterior vertebrarterial foramen	.0165
Expanse of postzygapophyses of a lumbar vertebra	.0230
Diameter radius at middle of shaft	.0100
Greatest distal width of radius	.0220
Diameters carpal surface { vertical	.0140
Diameters carpal surface { transverse	.0185
Diameters of unciform { vertical (interiorly)	.0130
Diameters of unciform { anteroposterior (greatest)	.0140
Diameters of unciform { transverse (in front)	.0150
Diameters head metacarpal I { anteroposterior	.0130
Diameters head metacarpal I { transverse	.0120
Length of metacarpal I	.0310
Width metacarpal I at epicondyles	.0110
Diameters head metacarpal II { anteroposterior	.0110
Diameters head metacarpal II { transverse	.0070
Length of metacarpal II (or III)	.0400
Width do. at epicondyles	.0120
Diameter head of M. III (or II) { anteroposterior	.0125
Diameter head of M. III (or II) { transverse	.0075

Measurements of No. 1.	M.
Diameters head of M. IV { anteroposterior	.0120
Diameters head of M. IV { transverse (at middle)	.0070
Width of patella near middle	.0190
Diameters of tibia .07 M. from astragalus { anteroposterior	.0185
Diameters of tibia .07 M. from astragalus { transverse	.0130
Anteroposterior width of astragalar face	.0200
Total length of astragalus	.0310
Diameters of the trochlea { length on groove	.0210
Diameters of the trochlea { width above	.0160
Diameters of the trochlea { elevation externally	.0130
Greatest width of astragalus below	.0225
Length anterior to internal crest of trochlea	.0100
Diameters head of metatarsal III { anteroposterior	.0130
Diameters head of metatarsal III { transverse (in front)	.0110
Diameters head of metatarsal IV { anteroposterior	.0140
Diameters head of metatarsal IV { transverse	.0105
Diameters head M. V { without tuberosity { anteroposterior	.0120
Diameters head M. V { without tuberosity { transverse { with lateral facet	.0080
Diameters head M. V { without tuberosity { transverse { without do.	.0040
Diameters head M. V { transverse over all	.0170
Length Mt. V	.0460
Width do. at epicondyles	.0120
Width do. at condyle above	.0065
Width of M. III or IV at epicondyles	.0120
Width of proximal end of phalange	.012
Length of smaller phalange (1st series)	.0230
Proximal diameter do. { vertical	.0070
Proximal diameter do. { transverse	.0110
Ungual phalange, vertical diameter of cotylus	.0090

The specimen which has been partially described in the preceding pages as No. 2, has many pieces which are identical with those preserved in specimen No. 1. Among these may be mentioned the glenoid cavities of the squamosal bone. These display, besides the large postglenoid process, a well developed preglenoid ridge, as in *Arctocyonidæ*, *Oxyænidæ* and *Mesonychidæ*. A large distal caudal vertebra of elongate form, indicates a long tail. An articular extremity of a flat bone is intermediate in form between the proximal end of the marsupial bone of *Didelphys* and that of *Sarcophilus*. Its principal and transverse articular surface is transversely convex, as in the latter (*S. ursinus*), but the lesser articular face is separated from it by an even shorter concave interspace than in the opossum. It has almost exactly the form of that of the latter animal. It is a short, flat cone, with two faces presenting on the same side, the one part of the concavity mentioned, the other flat and presenting away from it. This

piece has a slight resemblance to the very peculiar head of the fibula in the oppossum, but is not like that of *Sarcophilus ursinus*. I, however, think it much more probably the proximal extremity of a marsupial bone.

A supposed *cuneïform* is subtransverse in position, and resembles in general those of *Oxyæna* and *Esthonyx*. It has the two large transverse proximal facets, the anterior one-quarter wider than the posterior. The distal facet (trapeziotrapezoidal) is simple. The *navicular* is much like that of *Oxyæna forcipata*, but is more robust. Its external tuberosity is flattened anteroposteriorly, and is produced proximally. The three distal facets are well marked, the median a little wider than the external, while the internal is subround, convex, and sublateral in position. The *entocuneïform* is a flat bone, with cup-shaped facet for the navicular, and narrow facet for the first metatarsus. This facet is transverse transversely, and concave anteroposteriorly. It shows (1), that there is a pollex; (2), that it is probably small; and (3), that it was not opposable to the other digits, as is the case in the opossum. (4). It does not show whether the pollex has an unguis or not.

Measurements No. 2.		M.
Transverse width condyle of mandible		.0230
Anteroposterior width condyle of mandible (at middle)		.0103
Diameters head of *os marsupii*	transverse	.0220
	anteroposterior	.0068
Diameters cuneïform	vertical	.0075
	anteroposterior	.0115
Diameters navicular	vertical in front	.0085
	transverse	.0180
	anteroposterior (middle)	.0110
Diameters ectocuneïform	vertical at middle	.0100
	anteroposterior (middle)	.0140
	transverse distally	.0060

Two other bones of specimen No. 2 I cannot positively determine. The first resembles somewhat the trapezium of *Sarcophilus ursinus*, and still more that of *Didelphys*. I will figure it, as a description without identification will be incomprehensible. The next bone is of very anomalous form. It may be the magnum, which is the only unrecognized bone of importance remaining, or it may be a large intermedium. It has no resemblance to the magnum of any mammal known to me. It was evidently wedged between several bones, as it has eight articular facets. Two are on one side; the largest (convex and oval) is on one edge; three are on one end, and two, the least marked, are on the other flat side, opposite to the first.

Restoration. We can now read the nature of the primitive mammal *Mioclænus ferox*, in so far as the materials above discussed permit. It was a powerful flesh-eater, and probably an eater of other things than flesh. It had a long tail and well-developed limbs. It had five toes all around, and the great or first toe was not opposable to the others, and may have been

rudimental. The feet were plantigrade and the claws prehensile. The fore feet were well turned outwards. There were in all probability marsupial bones, but whether there was a pouch or not cannot be determined. These points, in connection with the absence of inflection of the angle of the lower jaw, render it probable that the nearest living ally of the *Mioclænus ferox* is the *Thylacynus cynocephalus* of Tasmania. The presence of a patella distinguishes it from Marsupials in general. Its dentition, glenoid cavity of the skull and other characters, place it near the *Aretocyonidæ*. Should the forms included in that family be found to possess marsupial bones, they must probably be removed from the *Creodonta* and placed in the *Marsupialia*.

This species is about the size of a sheep. The bones are stated by Mr. Baldwin, who discovered it, to be derived from the red beds in the upper part of the Puerco series.

MIOCLÆNUS BUCCULENTUS, sp. nov.

A part of the right maxillary bone which supports three molars indicates this species. The molars are P-m IV, M. i and M. ii. This series is characterized by the remarkably small size of the fourth premolar, and large size of the second true molar. The first true molar is intermediate.

The fourth premolar consists of an external cone and a much smaller internal one. There is a weak posterior basal cingulum. The reduced size of the internal cone suggests the probability that the third premolar has no internal cusp, and that there may be but three premolars. In either case the species must be distinguished from *Mioclænus*.

The first and second true molars have conic well separated external cusps, and a single pyramidal internal cusp. The intermediate tubercles are distinct. There is a posterior cingulum which terminates interiorly in a flat prominence. There is an anterior cingulum and a strong external one, which form a prominence at the anterior external angle of the crown. Enamel wrinkled.

Measurements of Superior Molars.		M.
Length of bases of P-m. iv M. i and ii		.0180
Diameters P-m. iv	anteroposterior	.0040
	transverse	.0046
Diameters of M. i	anteroposterior	.0060
	transverse	.0065
Diameter of M. ii	anteroposterior	.0070
	transverse	.0085

MIOCLÆNUS SUBTRIGONUS Cope.

This species has been known hitherto* from a palate with three molars. I am now able to give the characters of the inferior molar series, which have been found, by Mr. Baldwin, associated with the true superior molars. Of the latter it may be remarked that the second true molar is not so much

*American Naturalist, 1881, 490-1.

longer than the first as in *M. bucculentus*, although the difference in size is very evident. The third is smaller than the first, and ovoid in outline, while the first and second are subquadrate. The external cusps are conic and widely separated and the intermediate areas are distinct. There is a cingulum all round the crown of the last two, and round that of the first except at the inner side, and at the anteroëxternal angle.

The last three inferior premolars are higher than long at the base, and are compressed and the apex acute. The posterior edge of the third and fourth is truncate, and simple. Each has a posterior cingulum which forms a narrow heel on the fourth. No other cingula. Of the true molars only the second is wanting. The form of these is like those of the *M. ferox*, with the cusps more prominent. The first only has trace of the anterior V; in the others, the two anterior tubercles are opposite and connected by a short anterior ledge. The heel of the first consists of a basin bounded by these tubercles, of which the external is pyramidal and largest. The median posterior is small. The heel of the third is narrow and prominent, and the internal lateral tubercle is represented by a short raised edge. The enamel of all the molars is wrinkled, and the inner side of the premolars is grooved with the height of the crown. A weak external cingulum on M. iii.

Measurements.	M.
Length of last three superior molars	.0265
Diameters of M. i { anteroposterior	.0060
Diameters of M. i { transverse	.0060
Diameters of M. ii { anteroposterior	.0062
Diameters of M. ii { transverse	.0072
Diameters of M. iii { anteroposterior	.0047
Diameters of M. iii { transverse	.0060
Length of last inferior molars	.0340
Length of last three premolars	.0140
Length of P-m. iv	.0050
Elevation of P-m. iv	.0050
Diameters of M. i { anteroposterior	.0057
Diameters of M. i { transverse	.0042
Diameters of M. iii { anteroposterior	.0070
Diameters of M. iii { transverse	.0035

Rather larger than the pine weasel, *Mustela americana*.

MIOCLÆNUS CORRUGATUS, sp. nov.

This species is known from a right maxillary bone which contains the last four molar teeth, with parts of pelvis and other bones of one individual.

This species is intermediate in size between the *M. protogonioides* and *M. ferox*, as the following measurements of the second superior true molar show:

	M. protogonioides.	*M. corrugatus.*	*M. ferox.*
Diameter, transverse	.011	.0118	.015
" anteroposterior	.008	.010	.013

The superior molars are more nearly quadrate than in the other species of the genus, owing to the better development of the posterior internal tubercle, which is, however, as in the others, a mere thickening of the posterior cingulum. It is wanting from the last superior molar. The cusps on the true molars are as in the *M. ferox*, small, and not large and closely placed as in *M. protogonioides*. The intermediate ones are nearly obsolete. The crowns are all entirely surrounded by a cingulum. The entire enamel surfaces wrinkled so as to be rugose, although the teeth are those of an adult and well used. The second superior molar is larger than the first, exceeding it in the transverse rather than the fore-and-aft diameter. The third is the smallest, and is of oval form with obliquely truncate external face. It is less reduced than in the *M. turgidus*.

The fourth premolar consists of a strong compressed-conic cusp with three basal cusps of small size, viz., an anterior, a posterior, and an internal. The last is the larger, though small, is formed like a heel, and is connected with the others by a cingulum. No external cingulum.

Measurements.		M.
Length of last four molars		.036
Diameters P-m. iv	anteroposterior	.010
	transverse	.008
" M. i	anteroposterior	.010
	transverse	.010
" M. iii	anteroposterior	.008
	transverse	.011

From the Upper Puerco beds.

PANTOLAMBDA BATHMODON Cope, American Naturalist, 1882, p. 418.

In describing this genus and species, I remarked, loc. cit., that they were "founded on a mandibular ramus, which supports the first true molar, and the last two premolars. The characters of these teeth remarkably resemble those of *Coryphodon*. * * * It will be for additional material to demonstrate whether this genus belongs to the *Amblypoda* or *Perissodactyla*."

A considerable part of the skeleton of this species having been recently sent me by Mr. D. Baldwin, I am able to throw much light on the affinities of this curious genus.

In the first place, the phalanges (not ungual), show that the genus is ungulate. Secondly, the astragalus has a large distal facet for the cuboid bone. This proves that the genus cannot be referred to the Taxeopod order. The question as to whether it belongs to the *Amblypoda* or the *Diplarthra* would be decided by the carpus, but that part is unfortunately not preserved, and I have to rely on empirical indications for a provisional determination. Apart from the astragalus, the characters are those of the *Condylarthra* rather than of the *Perissodactyla*, and it is therefore to be supposed that the carpus has also the characters of that order. This would

place the genus in the *Pantodonta*, which has the carpus nearly that of the *Taxeopoda*, and the tarsus of the *Diplarthra*. The points of resemblance to the *Condylarthra* are the following: The ilium is narrow. The humerus has an epitrochlear canal. The superior molar teeth have but one internal lobe. The resemblances to the *Pantodonta* are these: The cervical vertebræ are plane and short. The femur has a third trochanter. The premaxillary bone in dentigerous. The astragalar trochlea is as in the *Periptychidæ*, and the *Proboscidia*; that is without groove, and slightly convex anteroposteriorly, thus differing from that of the *Pantodonta*. The dentition is especially like that of the *Amblypoda* in general, and that of the superior series is unlike anything known in the *Diplarthra*.

I propose to place this genus in the *Amblypoda* for the present, next to the *Pantodonta*, but it cannot enter that sub-order on account of the form of its astragalus. The sub-orders of *Amblypoda* will be defined as follows:

Astragalus with a head distinct from trochlea, with distal articular facets.....*Taligrada.*
Astragalus without head; distal facets subinferior.....*Pantodonta.*

In the sub-order *Taligrada*, the single family *Pantolambdidæ* presents the following characters:

Superior and inferior molars with the cusps developed into Vs. Postglenoid process present; postympanic and paroccipital not distinct. All the vertebræ with plain articulations. Humeral condyles without intertrochlear ridge. Femur with third trochanter. Digits of posterior foot probably five. Metapodial keels small and posterior.

Of this family *Pantolambda* is as yet the only known genus. Its leading characters are as follows:

Canine teeth distinct; dental series continuous. Superior molars all triangular, that is with a single internal cusp. External cusps of premolars unknown; of molars two. Internal cusp V-shaped, sending its horns externally as cingula to the anterior and posterior bases of the external side of the crown, without intermediate tubercles. Inferior true molars with a crown of two Vs, the anterior the more elevated. Premolars consisting of one open V, with a short crest on a short heel, as in *Coryphodon*. Dental formula $I\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{3}{3}\frac{4}{4}$; M. $\frac{3}{3}$; the last inferior with a heel. A strong sagittal crest. Auricular meatus widely open below. Large postparietal, postsquamosal and mastoid foramina.

Cervical vertebræ rather short; other vertebræ moderate, the lumbars not elongate. A large tail. Humerus with large internal epicondyle. Femur with all the trochanters large. Ilium with the anterior inferior spine well developed. Metacarpals short, plantigrade. Phalanges of second series flat, and of subquadrate outline. The astragalus has a wide head, but no neck, as it is not separated from the tochlear portion by a constriction. It is as wide as the trochlear portion, but about one-third of its length extends within the line of the malleolar face of the trochlear portion. The

navicular face is flat, that of the cuboid bone is convex vertically, and one-half as long horizontally as the navicular, and only half as deep. These two facets are continuous with the sustentacular below. Interior to all of these, on the internal tuberosity of the head is a sub-round facet looking inwards, like that characteristic of the genus *Bathmodon*, but relatively larger. A continuous facet is seen on the adjacent edge of the navicular. The use of these facets is unknown.

The brain case indicates small and nearly smooth hemispheres, extending with little contraction into a rather large cerebellum. The olfactory lobes are produced anteriorly at the extremity of a rather long isthmus.

If we consider the dentition alone, *Pantolambda* is the ancestor of the *Coryphodontidæ*. The history of the feet requires further elucidation.

The *Pantolambda bathmodon* is about as large as a sheep.

From the upper beds of the Puerco.

MIXODECTES PUNGENS, gen. et sp. nov.

Char. Gen.—The position of this genus is uncertain, but may be near to *Cynodontomys* Cope, which I have provisionally placed among the Prosimiæ*. It is only known from mandibles, which have presumably the following dental formula. I. 0; C. 1; P-m. 4; M. 3. An uncertainty exists as to the proper names of the anterior teeth, which cannot be decided until the discovery of the superior series. For instance the formula may be; I. 1; C. 1; P-m. 3.

The supposed canine is a large tooth, issuing from the ramus at the symphysis like a rodent incisor, and has an oval section, with long diameter parallel to the symphysis. The crown is lost from all the specimens. The second tooth is similar in form to the first, but is much smaller. It is situated posterior and external to the first. The next tooth is still smaller and is one-rooted. The third and fourth premolars have simple conic crowns, and more or less developed heels without cusps. The true molars are in general like those of *Pelycodus; i. e.*, with an anterior smaller, and a posterior triangle or V. The supplementary anterior inner cusp is quite small, while the principal anterior inner is elevated. The posterior inner is much more elevated than in the species of *Pelycodus*. Last inferior molar with a fifth lobe.

This genus cannot be referred to its place without additional material, but the parts discovered indicate it to be between *Pelycodus* and *Cynodontomys;* either in the *Mesodonta* or the *Prosimiæ*. I may here remark that in defining the latter genus I was in doubt as to the number of the inferior premolars. The discovery of the present genus renders it probable that it has three such teeth, and that the anterior two are each one-rooted.

Char. Specif. The mandible of the *Mixodectes pungens* is about the size of that of the mink. Its inferior outline is straight to below the second premolar, whence it rises upwards and forwards like that of a rodent. The anterior masseteric ridge is very prominent, but terminates below the

* Paleontological Bulletin No. 34, p. 151.

middle of the ramus. Inferior masseteric ridge much less pronounced. The inferior part of the ramus is robust below the base of the coronoid process, but there is no indication of recurvature of the edge. Mental foramina two; one below the front of the first true molar, and one below the second premolar.

The oval base of the canine is not flattened on either side; that of the second tooth is flattened on the inner side. There is a great difference between the sizes of the last three premolars. The fourth is twice as large as the third, and the second, judging from the space and the size of its alveolus, was much smaller than the third, and the crown was probably a simple acute cone. The crown of the third is of that form, with the addition of a short heel. The long axis of the base of the crown is diagonal to that of the jaw. The fourth premolar has a relatively larger heel than the third, but it is shorter than the diameter of the base of the cusp. Its posterior edge is elevated. The cusps of the anterior pair of the true molars are elevated, but the interior is the most so. The supplementary one is not exactly in the line of the interior border of the crown. Each of the inner cusps are connected with the base of the external by a ridge, which together form a V. The posterior base is nearly surrounded by a raised edge, which rises into cusps at the posterior lateral angles. Of these the internal is the more prominent. The edge connecting these cusps is slightly convex backwards, and evidently bears a part in mastication. The lateral borders of the last molar are somewhat expanded, and the fifth lobe is very short. No cingula on any of the teeth.

Measurements.	M.
Length of dental series from "canine" exclusive	.0265
" true molar series	.0140
Diameters "canine" longtitudinal	.0040
Diameters "canine" transverse	.0030
Long diameter of base of "P-m. i"	.0028
" " " P. m-ii	.0017
Diameters P-m. iv vertical	.0055
Diameters P-m. iv anteroposterior	.0050
Diameters M. ii transverse	.0038
Diameters M. ii anteroposterior	.0050
Length of crown of M. iii	.0060
Depth of ramus at P-m. iii	.0090
" " M. iii	.0100

MIXODECTES CRASSIUSCULUS, sp. nov.

This mammal is represented by fragments of two mandibles from different individuals; one less and the other more worn by mastication. The species differs from the last in its greater size, and in the relatively greater length of the last inferior molar. The length of the posterior four molars of the *M. pungens* equals that of the three true molars of the *M. crassius-*

culus; and the last true molar of the latter is half as long again as the penultimate, while in *M. pungens* it exceeds it but little.

The best preserved true molar is the second. Its most elevated cusps are the anterior and posterior inner, of which the anterior is subconic and more elevated. The anterior external cusp is crescentic in section, and sends crests to the supplementary, anterior, inner and the posterior anterior inner, both of which descend inwards. The posterior crest reaches the posterior base of the anterior inner cusp.

The posterior external cusp is an elevated angle, sending crests forward and backwards. The former reaches the base of the anterior external cusp (not reaching the inner), while the latter passes round the posterior edge of the crown. As in *M. pungens*, it is convex posteriorly, and rises to the posterior internal cusp. In both species its appearance indicates that it performs an important masticatory function in connection with the superior molar. No cingula.

Measurements.		M.
Length of bases of M. ii and iii; (No. 2)		.0125
" base of M. iii; (No. 2)		.0070
Diameters crown M. ii; (No. 1)	anteroposterior	.0056
	transverse	.0050
Depth of ramus at M. ii; (No. 1)		.0100

PERIPTYCHUS CARINIDENS Cope.

Additional specimens of this species demonstrate that the last inferior molar has a different form from that of the *P. rhabdodon*. While of the same length, it is narrower throughout, conformably with the smaller size of all the other molar teeth.

PHENACODUS CALCEOLATUS, sp. nov.

This species is founded on fragments of the skull and limbs, with teeth, of a single individual. The teeth consist of two superior and four inferior molars of one side, and a smaller number of those of the opposite side.

The teeth are of the size of those of the *Phenacodus puercensis*, and like that species, there is no median external cingular cusp of the superior molars. In these teeth the external basal cingulum is weak, but there is a strong anterior cingulum, distinct from any of the cusps. No internal cingulum. External cusps conical, well separated; intermediate cusps rather large; internal cusps rather large, close together, but deeply separated. The last superior molar is reduced in size. It has well developed anterior and posterior cingula, a weak external, and no internal cingula. The intermediate tubercles are rather large, and there is one large internal tubercle.

The heel of the last inferior molar is short, wide and rounded. The posterior tubercle is but little behind, opposite the posterior internal tubercle. The latter is separated from the anterior inner by a deep fissure, while the opposite side of the crown is occupied by a large median exter-

nal cusp, which has a semicircular section. The large anterior cusps are confluent on wearing. No anterior cingulum in the worn crown. The crowns of the first and second true molars of the specimen are rather worn. They show that the posterior median tubercle is very indistinct and probably absent. The bases of the smaller inner cusps are round, and on wearing unite with the larger external cusps. Of the latter the posterior is the larger. Anterior cingulum rudimental or wanting. No lateral or posterior cingula. The principal peculiarity of the lower dentition of this species and the one from which it is named, is the form of the third or fourth (probably third) premolars, both of which are preserved. They have a compressed apex, which descends steeply to the anterior base, without basal or lateral tubercle. The base of the crown spreads out laterally behind, and is broadly rounded at the posterior margin, so as to resemble the toe of a wide and moccasined foot. It is depressed, the surface rising to the apex from a flat base.

Measurements.		M.
Diameters of second superior molar	anteroposterior..	.0080
	transverse.....	.0100
Diameters of last superior molar	anteroposterior.....	.0067
	transverse.....	.0085
Length of inferior true molars.....		.0258
Diameters of M. ii	anteroposterior.....	.009
	transverse.....	.008
Diameters of M. iii	anteroposterior.....	.0085
	transverse	.0068
Diameters of the P-m. iii	anteroposterior.....	.008
	transverse.....	.005

About the size of the *P. puercensis*.

NOTE ON THE MAMMALIA OF THE PUERCO AND THE ORIGIN OF THE QUADRITUBERCULATE SUPERIOR MOLAR.—It is now apparent that the type of superior molar tooth which predominated during the Puerco epoch was triangular; that is, with two external, and one internal tubercles. Thus of forty-one species of Mammalia of which the superior molars are known, all but four have three tubercles of the crown, and of these thirty-eight triangular ones we may except those of three species of *Periptychus*, which have a small supplementary lobe on each side of the median principal inner tubercle.

This fact is important as indicating the mode of development of the various types of superior molar teeth, on which we have not heretofore had clear light. In the first place, this type of molar exists to-day only in the insectivorous and carnivorous Marsupialia; in the Insectivora, and the tubercular molars of such Carnivora as possess them (excepting the plantigrades). In the Ungulates the only traces of it are to be found in the molars of the *Coryphodontidæ* of the Wasatch, and *Dinocerata* of the

Bridger Eocenes. In later epochs it is chiefly seen only in the last superior molar.

It is also evident that the quadritubercular molar is derived from the tritubercular by the addition of a lobe of the inner part of a cingulum of the posterior base of the crown. Transitional states are seen in some of the *Periptychidæ* (*Anisonchus*) and in the sectorials of the *Procyonidæ*.

On the Brains of the Eocene Mammalia Phenacodus and Periptychus. By E. D. Cope.

(*Read before the American Philosophical Society, December 15, 1882.*)

PHENACODUS PRIMÆVUS Cope.

A cast of the cranial cavity gives the following as the general characters of the brain. The cerebal hemispheres are remarkably small, each one being less by one-quarter than the cerebellum. They are separated from the latter and from the large olfactory lobes by strong constrictions. The posterior one is occupied by a thick tentorium. In like manner a wide groove for a robust falx separates the hemispheres above, a notch represents the sylvian fissure, and the lobus hippocampi is quite large. The vermis of the cerebellum is quite distinct, and the lateral lobes are large. They are impressed laterally by the petrous bones as in various ruminants. The anterior columns of the medulla are not visible. There are traces of the convolutions on their hemispheres.

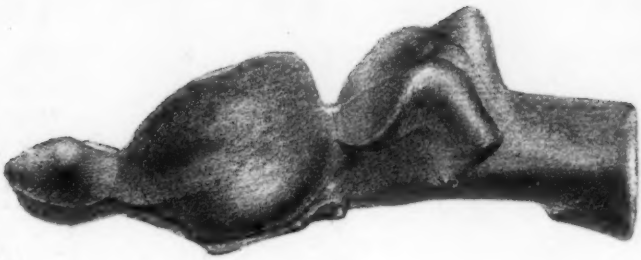
The brain displays the following more special features. The olfactory lobes are as wide as long, and they diverge, having two external sides. In section they are triangular, presenting an angle downwards. The hemispheres are depressed, and wider posteriorly. They are well separated from each other and from the cerebellum; so much so that it is quite probable that the copora quadrigemina are exposed. Their outlines are however not distinguishable on the flat surface which connects the hemispheres posteriorly. No further indication of sylvian fissure can be seen in the cast beyond an entering angle defining the lobus hippocampi anteriorly. The latter is prominent externally, and less so downwards. There are distinct indications of convolutions. There are three on each side above the sylvian convolution, and a fourth extends from the sylvian upwards and posteriorly below the posterior part of the third or external convolution. The sulci separating the convolutions are very shallow. The internal and external convolutions unite anteriorly, passing round the extremity of the median convolution. The space between this gyrus and the base of the olfactory lobe is only three millimeters.

The cerebellum is larger than a single hemisphere. Its superior surface is somewhat flattened, and descends forwards; the lateral boundary of this face is a projecting edge which rises behind to an angle of the vermis. The posterior face is shorter than the superior, and is vertical. It is separated by a space from a very prominent lateral convolution, while the region of the flocculus is concave from the internal form of the ascending portion of the petrous bone. This concavity is open anteriorly. The base of the fifth pair of nerves is below its apex, and that of the sixth below the inferior extremity of the lateral convolution. The section of the medulla oblongata is a transverse oval; its inferior face and that of the pons varolii, smooth. A deep fossa just anterior to the bases of the optic nerves.

Measurements of brain.	M.
Length from vermis to olfactory lobes inclusive	.070
" of olfactory lobes from above	.015
" of hemispheres, from above	.030
" of cerebellum from above	.024
Depth of olfactory lobe	.010
" of hemisphere	.023
" of cerebellum and medulla	.026
" of medulla at vermis	.015
Width of olfactory lobes at middle	.030
" of hemispheres in front	.044
" " behind	.044
" of cerebellum	.036
" medulla at vermis	.020

PERIPTYCHUS RHABDODON Cope.

I have obtained a cast of the top and sides of the cerebral hemispheres, and the proximal portion of the olfactory lobes, from a skull of a *Periptychus* in which the teeth are preserved, and prove the species to be the *P. rhabdodon*. The olfactory lobes are enormous, and the hemispheres small and very flat. The *mesencephalon is entirely exposed.* The cerebral hemispheres are very flat, and are only differentiated from the olfactory lobes, by a moderate contraction and depression, which forms the peduncle of the latter. Only the proximal part of the olfactory lobes is preserved, but this expands so as to be only a little narrower than the hemispheres. The peduncle has a ridge on the median line, and a shallow fossa on each side of it. The lateral outlines of the hemispheres diverge, and the widest part is posterior. There is no indication of sylvian fissure. The transverse section of the hemispheres would be a flat arch, but for the presence of a longitudinal oval protuberance on each of them, which do not quite touch the median line, and which have definite boundaries. If their limits determine the size of the cerebral hemispheres, then the latter are wider



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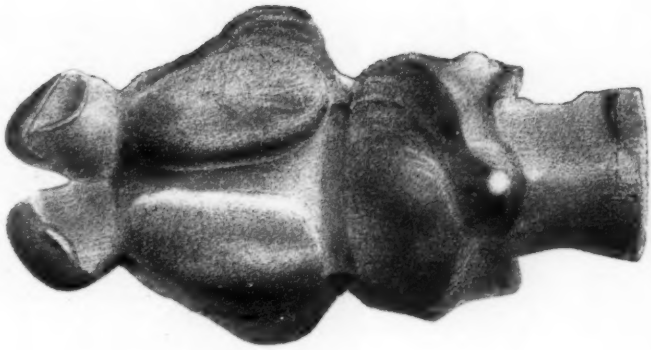

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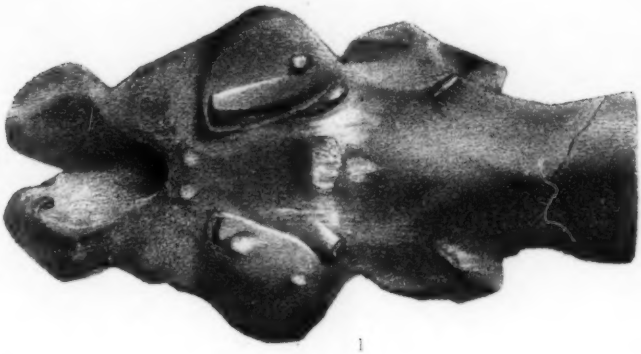
T. Sinclair & Son, Lith. Phila.

PHENACODUS PRIMAEVUS ½



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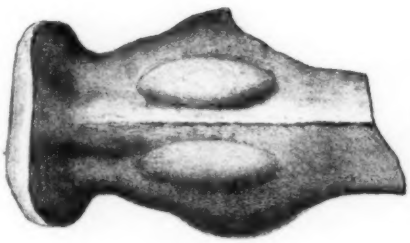

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T. Sinclair & Son, Lith. Phila.

1. PHENACODUS PRIMAEVUS ¼. 2-3. PERIPTYCHUS RHABDODON ½.

than long, but they probably pass gradually into the mesencephalon behind them. These bodies remind one of the corpora olivæformia, and may represent the superior or median frontal convolutions. They are probably, however, not to be homologized with any convolutions, representing rather the cerebral vault of the lateral ventricle. Posterior to them the flat surface descends gently without indication of copora quadrigemina or other irregularity, and at a distance about equal to the length of the oval bodies, it begins to rise gently. The cranium is broken here, and no cast of the cerebellum was obtained.

I may remark that the cranium from which this cast is taken is not crushed, and that it consists of parts of the parietal and squamosal bones only. The latter remain as far as the incurvature to the pterygoid processes in front of the glenoid cavity.

Measurements of brain.	M.
Length from posterior rise to base of olfactory lobes....	.037
Length of oval bodies of hemispheres.....	.018
Width of proximal part of olfactory lobes.....	.027
Width of olfactory peduncles.....	.021
Length from olfactory lobes to oval bodies of hemispheres.....	.005
Diameter of hemispheres at posterior part of oval bodies.	.038
Depth from sagittal crest to olfactory lobes	.024

EXPLANATION OF PLATES.

Plate I.

Casts of the brain case of *Phenacodus primævus* Cope, natural size.

Fig. 1. Lateral view.
Fig. 2. Superior view.
Fig. 3. Anterior view.
Fig. 4. Posterior view.

Plate II.

Fig. 1. Brain of *Phenacodus primævus*, inferior view.
Fig. 2. Cast of brain case of *Periptychus rhabdodon*, superior view.
Fig. 3. Cast of brain case of *Periptychus rhabdodon*, lateral view.

Photodynamic Notes, VII. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, January 19, 1883.)

302. *Combined Cometary Harmonics.*

In Note 295, I showed that the primitive phyllotactic wave-tendencies in the spectrum of Comet Wells, were modified by linear oscillations, and also by two seemingly independent harmonic progressions. One of the arithmetical progressions which formed the harmonic divisors had a missing term, $1 + b$, for which Huggins observed no corresponding line. Upon further examination, I find that the completion of the harmony, by inserting the provisional wave length, $\beta_1 = a \div (1 + b) = 4583.4$, furnishes a phyllotactic bond between the two observed harmonic progressions. For $4583.2 = \gamma + \frac{1}{5}(\beta - \gamma)$, and β_1 represents a projectile locus of rotary oscillation between β and γ. Moreover, the locus of the center of rotary oscillation, $\frac{1}{2}(\beta - \gamma) = 50.8$, helps to determine phyllotactically the value of a, since $\frac{1}{8}(\alpha - \beta) = 50.625$.

303. *Telephonic Analogy.*

The telephone shows the influence of harmonic oscillations in successive media of different elasticity, and it may perhaps furnish suggestions which will prove useful in investigating the persistence of solar energy. The atmospheric sound-waves strike the diaphragm, exciting metallic sound-waves; these, in the mechanical telephone, are transmitted through the wire to the receiving diaphragm, where they excite new atmospheric sound-waves, which awaken audible sound-waves in the tympanum of the listener. In the electric telephone, the metallic sound-waves modulate the electric waves, which are forwarded with much greater speed than the ordinary metallic waves, affecting the air in the receiver and the ear of the hearer in the same way as in the mechanical telephone. In a communication to the American Philosophical Society, March 21, 1873 (*Proc.*, xiii, 149-54), I pointed out harmonies of light and sound, which, with the identity of Note 280, account for these successive transformations. Berthelot's explosive waves, (Notes 276, 278) must similarly produce luminous and electrical waves in Sun's atmosphere, and thus contribute towards the maintenance of solar radiant energy.

304. *Amount of Solar Thermal Radiation.*

A. Ritter, (*Wied. Annalen*, 1882, No. 10), estimates the solar radiation at 14,000 calories per square metre per second. This is equivalent to 3976100 foot-pounds per square foot. If the Sun were surrounded with an atmosphere like our own, but of superficial density proportional to the gravitating pressure, the pressure would be about 420 pounds per square foot. The radiation, therefore, would be sufficient to maintain a constant circulation of the entire atmosphere, at the rate of 9467 feet per second, which is but little more than half as great as the explosive velocity of

H_2O (Note 298), about 1.56 times the molecular velocity of hydrogen, and about $\frac{1}{3}$ of the equatorial velocity of Sun's rotation. All of these relations are of an order of magnitude which tends to confirm the belief that solar radiation and gravitating circulation represent equal actions and reactions, and that dissociation and recombination within Sun's photosphere may maintain luminous, thermal, and actinic æthereal oscillations.

305. *Cometary Fugues.*

The spectral harmonies in Comet Wells (Notes 295, 302), as well as the planetary harmonies on which I based some of my successful predictions, (Notes 33, 133, 261, etc.), are of the nature of fugues, or harmonies which follow each other at certain intervals which are determined by rhythmic laws. The principle of the fugues being susceptible of indefinite extension in two directions, it is not strange that even the stars should bear witness to it (Notes 24, 46, 85, 111-5, 130-2, 154-5, 168, 262). Among the intra-modular positions which have verified my anticipations, two (Note 32) are known to be cometary; two represent the places of brilliant bodies which were seen by Watson and Swift, during the total solar eclipse of 1868, but which, having been seen by no subsequent observer, may also have been cometary; two were deduced from a comparison of planet-like shadows crossing Sun's surface, and one from sun-spots of various forms, which have a harmonic period; seven indicate periods which are in strict harmonic accordance with motions of our stellar system's chief centres, of nucleation (Sun), of condensation (Earth), and of nebulosity (Jupiter). All the indications seem somewhat likely to be cometary, rather than planetary, and thus confirmatory of Herschel's theory of nebular "subsidence." As the statements of these confirmations of cosmical harmonic motion are scattered among various papers, I collect them here, in order to show, at a glance, the character of the various accordances.

Harmonic.	Observed.	Authority.	Notes.
296.52	285.2	Forbes	32, 261
94.38	96.7	Forbes	32
.27	.267	De la Rue, S. and L.	33
.207	.209	Kirkwood	"
.185	.180	Gaillot	"
.167	.164	Gaillot and Mouchez	"
.167	.163	Stewart	133
.141	.140	Earth's day and year	33
.121	.123	Von Oppolzer	"
.1065	.1069	Solar rotation, $v_\gamma = v_\lambda$	"
.0199	.0195	Earth's day	"
.0109	.0109	Jupiter's day	"
.0076	.0074	Solar oscillation	"
.0058	.0057	Solar "subsidence"	"
.0047	.0047	Sun's surface	"

The seven loci which represent harmonies of nucleation, condensation and nebulosity, illustrate the tendency of waves in elastic media to maintain and propagate motions which are harmonically dependent upon their loci of orjgination.

306. *Velocity of Incandescence.*

Draper found that all solid bodies become incandescent at the same temperature, reaching red heat at 977° F., or at the absolute temperature of 1436°.4 F. This indicates a lift, against earth's superficial gravitation, of $h = 1436.4 \times 772 = 1,108,901$, or a velocity of $v = \sqrt{2gh} = 8435.9$ feet per second. The mean velocity of hydrogen molecules is 6050 feet, which is $.717 \times 8435.9$ feet. The velocity of incandescence is, therefore, within $1\frac{1}{2}$ per cent. of the parabolic orbital velocity which would correspond to a circular orbital velocity equivalent to the molecular velocity of hydrogen, ($6050 \times \sqrt{2} = 8556$). In other words, if the mean velocity of hydrogen, at the standard temperature, is a mean orbital velocity, its increase to a velocity of infinite projection would give the velocity of incandescence, or the velocity which creates æthereal disturbances of sufficient magnitude to cause luminous radiations. These disturbances are of the same order of magnitude as those which are indicated in Note 304, and they furnish new reasons for believing that the hypotheses of Siemens and Berthelot (Note 278) may suffice to account for the conservation of energy which is indicated by the fundamental equality, $v_\lambda = v_\varepsilon = v_\gamma$, (Note 280).

307. *Tails of Comets.*

Proctor (*Contemp. Rev.*, Oct. 1882) states some of the chief difficulties attending the attempts which have been made to explain the formation of comets' tails, by materials thrown off from the nucleus by solar repulsion, by actinic clouds, by tactic arrangement, or by electricity, and speaks of certain phenomena "which force upon us the belief that they are phenomena of repulsion, though the repulsive action is of a kind not yet known to physicists." He inclines, with Huggins, and "an American astronomer" whose name is not given, to attach great importance to electric action or something of a similar nature. He cites the notice by Huggins, of the remarkable persistence of meteoric trains in the rare upper atmosphere, where they sometimes last for more than three-quarters of an hour. The evidences of repellent action such as might be explained by electricity, of gravitating re-action, of luminous radiation from the sun in the direction of the axis of the tail, and of a general curvature of the extremity of the tail as if it were retarded in some way, are such as to need consideration in any attempts at explanation. All of these phenomena, except the one last named, may be correlated by the fundamental equality of Note 280. The curvature of the tails may be due to persistence of oscillation, combined with æthereal tendencies to orbital motion in times varying as $r^{\frac{3}{2}}$. The extreme tenuity of cometary matter points to a

relative elasticity which is much greater than that of air, and which must, therefore, be peculiarly subject to harmonic oscillations; the waves of light, like auroral flashes, which have often been seen in the tails, point to electric, phosphorescent, and luminous rhythms; the frequent interchanges between the tail and the nucleus, as well as the rupturing explosions and the formation of nucleoli, must be subject to the laws of phyllotactic and gravitating rhythm; if the æther is material, it must be influenced by rotational and orbital tendencies, even if its elasticity is so great as to prevent actual orbital motion, and hence the "actinic shadows" may be curved.

308. *Other Cometary Considerations.*

Phyllotactic distribution in organic growth, in frost tracery and other forms of crystallization, and in satellite or planetary groupings, points to a continuance of tendency, over periods which are proportional to the resistance interposed by the inertia of the particles or masses which partake of the distribution. When the inertia is very small, as in the æthereal interferences to which spectral lines are attributed, the adaptation to requirements of "extreme and mean ratio" may be nearly or quite instantaneous. We may, therefore, reasonably look for evidences of adaptation, such as are shown in Notes 295, 302 and 305, as well as for various modifications by other forms or kinds of harmonic tendency. Refraction of energy (Note 286), and Draper's "latent light," may also contribute to the curvature of tails, in a medium which is perhaps more tenuous than the "fourth form of matter," and which imparts sympathetic vibrations to the adjacent æther.

309. *Effects of Cometary Eccentricity.*

The tendencies to æthereal rotation and revolution about stellar centres may, perhaps, be so adjusted to other oscillatory tendencies as to oppose little or no resistance to planetary motions in orbits of small eccentricity. Most of the cometary orbits, however, are so eccentric that their *vis viva*, at every stage of their journey, is nearly twice as great as it would be if their paths were circular. Such amount of living force is more than sufficient, whenever there is any appreciable resistance, to produce and maintain luminous and thermal phenomena, of the same kind as occur in the explosive combinations of gases. The orbital energy may be resolved into two rectangular components, one of which passes through the sun, while the other is tangential to the path of the revolving æther. The latter may adapt itself so readily to the æthereal vortices as to make no disturbance; the former being perpendicular to the æthereal track, must encounter a continual resistance and retardation, unless it is compensated by luminous, electric, gravitating, or other kinetic undulations.

310. *Eccentricity at Mean Centre of Inertia.*

The fundamental identity (Note 280) represents a uniform velocity, and we may, therefore, look for evidences of primitive photodynamic influence

in the uniform velocities of important cosmical centres. One of these evidences is found in the proportion,

$$t_\alpha : t_\beta : : T_\alpha : T_\beta$$

In this proportion, t_α, is the orbital time at the chief centre of condensation (Earth); t_β, the orbital time at the centre of primitive nebulosity (Jupiter); T_α the time in which a photodynamic wave would traverse the secular eccentricity at the primitive centre of planetary inertia (Saturn); T_β the time in which the wave would traverse Saturn's semi-axis major. The accordance is shown by substituting the values, which give the proportion,

$$365.2564 : 4332.5848 : : .08431 : 1$$

Stockwell's estimate of Saturn's secular excentricity is .08433. T_α and T_β also represent the comparative living forces which would project a planet, against uniform resistance, through the distances traversed by the respective photodynamic waves.

311. *Harmonics of Terrestrial Acceleration.*

The cyclic oscillations at the chief centres of condensation and nebulosity would tend to produce corresponding accelerations through the action of central forces. An important harmony, which introduces the *vis viva* of acceleration, is shown in the proportion,

$$a^2_\alpha : a^2_\beta : : t_\alpha (t_\alpha + t_\beta) : t_\beta.$$

In this proportion, a_α is the rotary acceleration which Earth has undergone according to the nebular hypothesis; a_β, the acceleration according to Herschel's theory of "subsidence;" t_α and t_β have the same values as in the foregoing note. The value of a_α is $\left(366.2564 \div 2\pi\sqrt{\frac{r}{g}}\right)^2 = 338.22$; $a_\beta = 86164.1 \text{ sec.} \div 2\pi\sqrt{\frac{r}{g}} = 16.983$. Substituting these values we get

$$338.22^2 : 16.983^2 : : 396.62 : 1$$
$$396.62 : 366.2564 : : 1.0829 : 1$$
$$t_\alpha + t_\beta : t_\beta : : 1.0843 : 1$$

This harmony furnishes additional grounds for rejecting Delaunay's hypothesis of terrestrial retardation by tidal friction.

312. *Earth's Accelerated Rotation.*

I have already referred to the inconsistency of Delaunay's views with the nebular hypothesis. According to the form of that hypothesis which was taught by Laplace, at the time of nebular rupture the day and year should have been sychronous. In order to establish such sychronism at the present time, Earth's radius would need to be expanded ($\sqrt{366.2563} = 19.138$) times, and Laplace's terrestrial limit would be

$$\left(1 \text{ year} \div 2\pi\sqrt{\frac{r}{g}}\right)^{\frac{2}{3}} r, \text{ or } 338.218r.$$

This represents a comparative acceleration of the velocity of rotation which may be very closely represented by the quotient of (Jupiter's year × Earth's year) by (the sum of Jupiter's and Earth's years × Earth's day), or by $4332.5848212 \times 365.2563582 \div (4332.5848212 + 365.2563582) = 336.858$. As this equation introduces considerations of the chief centres of nucleation, nebulosity and condensation which must still be efficient, it furnishes another reason for caution in dogmatizing about tidal friction and thermodynamic laws.

313. *Joint Relations of Sun, Jupiter, Earth and Venus.*

A succession of important harmonic motions is shown in the relations of solar mass and density, which make $g_\odot t_\odot = v_\lambda$; the relation of Sun's mass to Jupiter's mass which makes Sun's surface the projectile locus, or secular perihelion centre of gravity, of Sun and Jupiter; the relations of terrestrial mass and density which make $g_\oplus t_\oplus =$ circular orbital velocity at the mean centre of gravity of Sun and Jupiter; and the relation of Venus to Earth which makes the incipient orbital *vis viva* of Venus (at secular aphelion) equal to Earth's mean orbital *vis viva*. If we adopt the British Nautical Almanac estimate of Sun's apparent semi-diameter (961.″83), the accordance of harmonic and computed values will be as follows:

	Harmonic.	Computed.	Authority.
Sun ÷ Venus	427326	427240	Hill.
" " Earth	330463	331776	(Oscillatory)
" " Jupiter	1047.879	1047.879	Bessel.

Earth's semi-axis major, 92,661,600.

314. *Joint Relations of Sun, Jupiter, Earth and Saturn.*

Alexander's harmony ($m_5 d_5^2 \doteq m_6 d_6^2$) is rendered more significant by Saturn's orbital situation at the nebular centre of planetary inertia, $(\Sigma m d^2 \div \Sigma m)^{\frac{1}{2}} \doteq \rho_6$. The slight deviation from exact accordance is very nearly, if not precisely compensated by the equation, Sun × Earth × Saturn $\doteq$ Jupiter^2. Alexander's approximation gives, $m_\odot = 3523.33\, m_6$; the other approximation gives, according to the foregoing note, $m_\odot = 3481.86$; the arithmetical mean being $m_\odot = 3502.1$, which differs by less than $\frac{1}{10}$ of one per cent. from Bessel's estimate. If ρ_5, ρ_6 represent Stockwell's estimates of the mean perihelia of Jupiter and Saturn, Bessel's estimates of their respective masses, and the equation (Sun ÷ Jupiter) × (Earth ÷ Jupiter) $= (\rho_5 \div \rho_6)^2$, give $m_\odot \div m_3 = 330240$. The harmonic accordances which were given in Note 310 corroborate these evidences of joint relations, and encourage a search for modifications by combined harmonies in other cases.

315. *Photodynamic Relations of Uranus and Neptune.*

The increasing number of harmonic influences with increasing distance from Sun, was illustrated in my *Relations of Mass*, (*Proc. A. P. S.*, xviii,

231), and in Note 156. A connection in which the harmonies of luminous undulation are more directly shown, gives the following relations:

$$(\rho_7 + \rho_3) \div 2\pi\sqrt{\frac{r_\circ}{g_\circ}} = v_\lambda$$

$$m_7 : m_3 : : \sqrt{\rho_3} : \sqrt{r_\circ}$$

$$\rho_7^3 : \rho_3^3 : : 1 \text{ year} : 1 \text{ day}$$

$$m_7 : m_3 : : p_7 : a_7$$

Stockwell's estimates of p_7 and a_7 (secular perihelion and secular aphelion of Uranus) are 17.687929 and 20.679233. The closeness of harmonic accordance is shown in the following comparison, in which I have used Struve's constant of aberration and the estimates of Note 313.

Velocity of light	$.43073r_\circ$	$.43077r_\circ$	Struve.
Semi-axis major of Uranus	$19.184\rho_3$	$19.138\rho_3$	Stockwell
Sun ÷ Uranus	22592	22600 ± 100	Newcomb.
" " Neptune	19324	19380 ± 70	Newcomb.

The division of the outer planetary belt is, therefore, such that the aphelion mass is in accordance with aphelion influence at the inner portion of the belt, while the perihelion mass is in accordance with perihelion influence. The further considerations of Note 156 add to the interest of this relationship.

316. *Joint Relations of Sun, Earth, Venus and Moon.*

The three foregoing notes seem to show that the harmonic influence of the chief centre of condensation (Earth) upon planetary masses, has been greater than that of the centre of nebulosity (Jupiter). We may, therefore, naturally look for additional illustrations of terrestrial influence within the dense belt, such as are given in Notes 8, 85, 156, 246-7, 254-6, 313. The estimate of μ, in Note 246, would become $1 \div 81.08$ if we adopt the value of ρ_3, which is given in Note 313. This value, if substituted in Note 8, would give 4.952 miles for the height of Earth's homogeneous atmosphere, through the proportion

$$\pi^2 \times 81.08 : 1 : : r_3 : .0012496r_3 : : 3962.8 : 4.952$$

The harmonies of Note 85 may well be studied in this connection. Stockwell's value for the secular perigee of Venus is $.9322648\rho_3 - .7744234\rho_3 = .1578414\ \rho_3 = 14{,}625{,}840$ miles $= 1.0252 \times (3 \times 4 \times 5)^2 \times 3962.8$ miles. The solar modulus of light, according to the same estimates, is $2213.37\rho_3 = 1.00073 \times 4 \times (3 \times 4 \times 5)^4 r_3$.

317. *The November Meteors.*

The relations which were pointed out in Note 315 may be supplemented by cometary indications of a character somewhat like those which led Forbes to his deduction of two supra-Neptunian loci (Notes 32, 305). The

secular aphelion of Uranus, or its locus of incipient subsidence (20.679233), represents a cometary major axis with a period of 33.2473 years. The period of the great "star-shower" of November 1833 and 1866 has been computed at "about 33.25 years." A similar cometary major axis (20.7072688), with a period of 33.315 years, would exactly represent, by its apsidal loci, the mean positions of Mars and Uranus. The special photodynamic indications of the first equation in Note 315, may be fairly presumed to have exerted an influence on each side of the central track, which would be sufficient to account for all of the approximations that have been indicated.

318. *Geological Time.*

Dr. Haughton (*Am. Journ. Sci.*, Nov. 1882) read before the American Association, in August, 1882, some "New views of Mr. George H. Darwin's Theory of the Evolution of the Earth-Moon System, considered as to its bearing on the question of the duration of Geological time." He cites Sir William Thomson's views as to the present rigidity of the earth, the probability that Saturn's rings consist of swarms of discrete meteoric stones, the low specific gravity of the outer planets, the recent researches connecting the periodic swarms of shooting stars with comets, Huggins's comparisons of the spectroscopic appearances of comets and incandescent portions of meteoric stones, and Prof. H. A. Newton's hypothesis that the asteroids may be extinct comets, to justify the position "that the earth and moon when they separated from the solar nebula, did so as a swarm of solid meteoric stones, each of them having the temperature of interstellar space." He then shows that the meteoric problem resembles the hydrodynamical problem, giving equations "in all respects similar to those derived by Mr. Darwin, from the hypothesis of a viscous earth" and placing "a cool earth and almost indefinite time at the disposal of geologists." These views are in accordance with Herschel's theory of subsidence, which I have found so abundantly illustrated by the actions and reactions of gravitation and æthereal elasticity (*Proc. A. P. S.*, ix, 283–8, 345–9, 355–60; x, 261–9, 368–79; xi, 103–7; xii, 392–417, 518–22; xvi, 184–92; xvii, 294–307, *et al*). Dr. Haughton refers to Prof. Newton's application of the same theory to account for the asteroids and some of the satellites, but he has made no allowance for the modifications of planetary and satellite arrangements which would result from harmonic motion.

319. *The Key-Note of Nature.*

Gardiner says (*Music of Nature*, 2d, Ed. p. 417): "In the fifteenth century, music was generally written in the key of F, and its relative D minor. This order of sounds was first adopted, probably on account of its being the most familiar to the ear, as it will be seen that the cries of animals, the buzzing of insects, the roar of storms, the murmurs of the brook, and some of the grandest sounds of the natural world, are to be referred to this harmony and may be denominated *The Key of Nature.*" In 1873, (*Proc.*

A. P. S., xiii, 151), I showed the accordance between the wave length of the principal Frauenhofer lines and of the homonymous notes of the twenty-third musical octave, the greatest difference being $2\frac{3}{4}$ per cent., and the closest approximation being at F, where the difference is less than $\frac{3}{4}$ of one per cent. In the arithmetical mean, the difference is less than $\frac{1}{4}$ of one per cent.; in the geometrical mean the accordance is exact. Langley, in a communication to the British Association, at Southampton, reported experiments which show a fundamental solar "tint which must approximately represent that at the photosphere, and which is most similiar to that of a hue near Frauenhofer's F." (*Am. Jour. Sci.*, Nov. 1882). See also Notes 41, 42, 235.

320. *Limit of Thermal Velocity.*

In Notes 58, 61, 62 and 102 I introduced some thermodynamic considerations which were based on interstellar photodynamic influence. In April 1865, (*Proc. A. P. S.*, x, 101) I called attention to the fact that "even the thermal currents are occasioned simply and solely by the varying gravitation of fluids of varying density," and in nearly all my physical papers I have been guided by the belief that all ultimate energy is radiant from or toward kinetic centres, the various forms, (luminous, thermal, electric, gravitating, etc.) being merely due to subordinate modifications of primitive radiations. The simultaneous radiation of light and heat from the Sun, the "Thomson Effect" (see *Am. Jour. Sci.*, xxiv, 379–87), and the phenomena of thermo-electricity, furnish strong *a priori* grounds for believing that the limit of thermal velocity, v_θ, is the same as the limit of luminous velocity, v_λ.

321. *Extension of Fundamental Equality.*

In throwing a ball into the air, the thermal equivalent of the projectile force is equal to the product of the mass by the sum of the retardations which result from gravitating influence, atmospheric resistance and all other opposing circumstances. In solar rotation, all the solar superficial particles are alternately projected from and drawn towards the chief centre of gravity of the system, in cyclical periods of half-rotation. The thermal equivalent of this projection represents the whole work of gravity for the time, $\frac{mgt^2}{2}$, and the corresponding velocity, v_θ, is equivalent to the velocity of light. This gives the following extension of the equation in Note 280:

$$v_\lambda = v_\varepsilon = v_\gamma = v_\theta.$$

The combination of centripetal and centrifugal tendencies which produces solenoidal terrestrial currents (Note 274), may, perhaps, suggest considerations which will be serviceable in general electrical research, and so lead to important developments of this fundamental equation.

322. *Disturbed Attraction.*

R. Lamont (*Jour. of Science*, Oct. 1882), says, "If we disturb the attraction which holds together the atoms of a chemical compound, whether it be in the solid, the liquid, or the gaseous state, we have this same emanation of light and heat. If, then, these great effects can be produced in our laboratories, what must result in our solar system from the continual struggle between attraction and centrifugal force?" I attacked the view that weight can be predicated of bodies at rest, as early as 1864 (*Proc. Am. Phil. Soc.*, ix, 357), and in February, 1868, I gave a summary of various phenomena which may be simply coördinated by the theory that motion, rather than rest, is the natural state of matter (*Proc. Am. Phil. Soc.*, x, 377–9). Although similar views had often been advocated by others, no attempt seems to have been made to confirm them by numerical measurements, prior to my investigations, which began in 1863 (*op. cit.*, ix, 283–8).

323. *Lunar Barometric Tides.*

The correlations of gravitating and magnetic tides (Notes 116–22), lend interest to Bergsma's observations of the lunar atmospheric tide at Batavia, 1866–80 (See *Nature*, Nov. 23, 1882, p. 79), a tide which appears to have been first observed by Luke Howard, in London. Assuming the lunar day to begin at the Moon's upper transit, the following are the phases above or below the mean, expressed in millimetres :—

	mm.		
1st max.	+ .057 at	lunar hour	1
1st min.	— .053 "	"	7
2d max.	+ .064 "	"	13
2d min.	— .060 "	"	19

Buchan's isobar of 29.9 in. = 759.45 mm. passes through the Malayan Archipelago. This is 6491 times the mean range (.117) of lunar disturbance, which is much greater than can be explained by simple gravitating tide. It is, however, in simple harmonic relation to the square of the mass. If $m_3^2 : \mu^2 :: 6491 : 1$, $m_3 = 80.56\mu$.

324. *Lunar-Tidal Rainfall at Batavia.*

"The influence of the moon's phases on the rainfall [at Batavia] is quite decided; for while the mean daily rainfall is .205 in., it rises at full moon to .248 in., from which time it gradually falls to .181 in. at the third octant, rises to .212 in. at the fourth octant, then falls to .184 in. at the fifth octant, and finally rises gradually to the maximum at the time of new moon. The important conclusion follows that the attractive influence of the moon, and consequently that of the sun, must be taken into account as factors concerned in bringing about oscillations of the barometer." These evidences of lunar-tidal influence upon rainfall are greater than those which I found at Philadelphia (*Proc. Am. Phil Soc.*, x, 523–37), about the same as at Barbadoes (*Ib.*, xiv, 195–216), but less strongly marked than at Lisbon (*Ib.*, xii, 178–90), and at San Francisco (*Ib.*, xii, 523–42).

325. *The Neptuno-Uranian Belt.*

All the proposed forms of the nebular hypothesis seem to require evidences of retrograde motion, such as are shown by the outer planets of our system. The successive harmonic influences of central condensation, conversion of orbital into rotary motion, incipient projection and incipient subsidence are shown by the proportions which were given in Note 315. If we take the oscillatory estimate, $m_0 = (2 \times 3 \times 4)^4\, m_3$, instead of the estimate in Note 313, we get $m_0 = 22656 m_7 = 19379 m_8$; $\rho_7 = 19.138 \rho_2$. Newcomb's mass-estimates are $m_0 = (22600 \pm 100) m_7 = (19380 \pm 70) m_8$. The observed value of ρ_7 is $19.184 \rho_2$, which is about $\frac{1}{4}$ of one per cent. greater than the harmonic value.

326. *Terrestrial Magnetic Vis Viva.*

Equation (1) of Note 91 may be modified by regarding v_0 as a mean proportional between Earth's mean orbital velocity and the velocity of light, and substituting the mass of the Telluric system, m_a, for Earth's mass. We then have,

$$m_0 v_0^2 : m_a v_\lambda^2 :: m_a v_\lambda^2 : m_3 v_0^2,$$

substituting $v_\lambda = \rho_3 \div 497.827$; $v_3 = 2\pi\rho_3 \div 31558149$; $m_0 = 1047.879 m_3$; we get $m_3 = 311.672 m_a$; $m_0 = 326594 m$, which differs by about $\frac{1}{8}$ of one per cent. from the magnetic estimate of Note 2 (327710). The identity of the velocity of electro-magnetic disturbance (*Maxwell, Electricity and Magnetism*, § 784) with the velocity of light, lends interest to this approximate coincidence. If we estimate $m_3 = 81.08\mu$, these two values of m_a give

$$m_0 = \frac{82.08}{81.08} \times 326594 m_3 = 330622 m_3; \quad \rho_3 = 92678000 \text{ miles.}$$

$$m_0 = \frac{82.08}{81.08} \times 327710 m_3 = 331752 m_3; \quad \rho_3 = 92783400 \quad \text{"}$$

The latter estimate of ρ_3 differs by less than $\frac{1}{400}$ of one per cent. from the value which is indicated by centres of nodal oscillation (Note 91).

327. *Cosmic and Chemical Harmonic Motions.*

A harmony which involves considerations of the conversion of orbital into rotary velocity, projectile *vis viva*, inertia of central condensation, and energy of chemical combination, is shown in the proportion

$$\rho_a : \rho_0 :: g_a : g_0 :: r_3^2 : h^2$$

in which ρ_a = Earth's primitive locus of orbital projection, or secular perihelion (Stockwell's estimate of secular eccentricity and the Brit. Naut. Alm. estimate of Sun's apparent semi-diameter give $\rho_a = 200.385 \rho_0$); g_a = mutual gravitating acceleration of two equal particles at distance h; g_0 = like acceleration at distance r_3; h = theoretical height of secondary centre of oscillation in explosive combination (Note 16). Solving the proportion, we get, $h = 279.943$ miles; $\rho_3 = 92739000$ miles; $m_0 = 331280 m_3$.

328. *Comparison of Harmonic Mass-Estimates.*

The estimates of planetary mass in Notes 313–5 are, in some respects, more simple than those in Note 156. This is especially the case with Uranus and Neptune.

	Note 156.	Notes 313–5.	Computed.
Sun ÷ Venus.	427630	427326	427240
Sun ÷ Earth,	331668	330463	331776
Sun ÷ Jupiter,	1047.879	1047.879	1047.879
Sun ÷ Saturn,	3503.22	3502.1	3501.6
Sun ÷ Uranus,	22602	22592	22600
Sun ÷ Neptune	19392	19324	19380

The relations of mass, density, and time, at the stellar centre of the system, are determined by the velocity of light; those at the chief nebular centre are influenced by the first harmony; those at the chief centre of condensation introduce the two preceding harmonies; those at the centre of planetary inertia show the combined influence of luminous undulation, nucleation, nebulosity and condensation. Venus and Uranus are rhythmically influenced by the chief centres of nucleation and condensation; Neptune is similarly influenced, though less directly, through its belt-connections with Uranus.

329. *Comparative Harmonic Estimates of Earth's Mass.*

In Note 15 I gave a summary of eighteen kinetic estimates of Earth's semi-axis major, giving the mean value, $\rho_3 = 92737100$ miles. Subsequent harmonic estimates, introducing various nodal influences which must be obviously operative, furnish data for the following comparisons:—

		Sun ÷ Earth.	ρ_3.
Chemical energy,	Note 16	331631	92,772,200 miles.
Oscillatory "	" 23, 91	331776	92,783,700 "
Inertia	" 152	331890	92,796,300 "
Rotating energy,	" 313	330463	92,661,600 "
Luminous "	" 326	330622	92,678,000 "
Magnetic "	" 326	331752	92,783,400 "
Gravitating "	" 327	331280	92,739,000 "

The mean values are 331345 ± 137, and $92,745,200 \pm 12900$. The latter value differs by less than $\frac{1}{11}$ of one per cent. from the one given in Note 15.

330. *Nodal Influence of Jupiter.*

The joint influence of Sun and Jupiter which was shown in Note 328, may be further illustrated by various nodal relations of planetary apsides. I indicated the importance of harmonic motion in determining apsidal positions, in a communication to the American Philosophical Society, April 2, 1869, more than eight years before Professor Stephen Alexander called the attention of the National Academy to the subject (*Proc. Am. Phil. Soc.*, xi, 103–7; xii, 405–7, 412, 520; xiii, 146, 196 (11); xiv, 635; etc.).

α. Jupiter's locus of incipient subsidence (secular aphelion), is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's semi-axis major.

β. Jupiter's mean subsidence-locus (mean aphelion) is nearly a mean proportional between Neptune's locus of incipient subsidence and Earth's mean projectile locus (mean perihelion).

γ. Jupiter's mean subsidence-locus is nearly a mean proportional between the semi-axes major of Mars and Uranus.

δ. Jupiter's semi-axis major is nearly a mean proportional between the mean projectile locus of Mars and the semi-axis major of Uranus.

ε. Jupiter's semi-axis major is nearly a mean proportional between the incipient subsidence locus of Uranus and the incipient projectile locus (secular perihelion) of Mars.

ζ. Jupiter's mean projectile locus is nearly a mean proportional between the incipient projectile-locus of Uranus and the mean projectile-locus of Mars.

η. All of Jupiter's orbital loci are at centres of explosive oscillation ($\frac{5}{7}$) of orbital loci of Saturn.

θ. Jupiter's mean subsidence-locus is at the nucleal locus of a condensing nebula, of which Saturn represents Laplace's atmospheric limit and Earth is the centre of condensation ; Earth's semi axis major being the unit radius, and Laplace's limit varying as the $\frac{4}{3}$ power of the nucleal radius. Accordances η and θ, which are the closest of all, are especially interesting on account of the variety of indications wh'ch they give of the harmonic influence of luminous undulations upon the four great centres of nucleation, condensation, nebulosity and planetary inertia.

The following table shows the closeness of agreement between the harmonic values and Stockwell's.

	Harmonic log.	Stockwell.	Dif. of logs.	Percentage of difference.
α	.7419330	.7418817	.0000513	$\frac{1}{64}$ of one per cent.
β	.7344514	.7345879	.0001365	$\frac{1}{91}$ " "
γ	.7329514	.7345879	.0016365	$\frac{3}{8}$ " "
δ	.7150274	.7162369	.0012095	$\frac{3}{4}$ " "
ε	.7165515	.7162369	.0003146	$\frac{1}{17}$ " "
ζ	.6974010	.6970763	.0003247	$\frac{1}{15}$ " "
η	. . . . .	. . . . .	.0000000	0 " "
θ	.7346221	.7345879	.0000342	$\frac{1}{125}$ " "

See also, Note 334.

331. *Photodynamic Significance of the Temperature of Space.*

Sir John Herschel estimated the absolute temperature of interstellar space as about one-half as great as Earth's mean superficial absolute temperature. If the former temperature is due to stellar radiations, every star must have opposite hemispheres which are exposed to different temperatures, as well as to different gravitating tendencies. The fundamental equation of velocity (Note 321), may be fairly presumed to be universal, so that all

stellar rotations may accord with solar rotation in alternately consuming and resuming, at alternate half-rotations, the photodynamic energy of all the superficial particles. At the outer limits of our æthereal system, the æther, if material, should rotate with the stars, so as to radiate and absorb heat like an ordinary atmosphere. A full discussion of conservation of energy in the several stellar systems, requires the consideration of time integrals of various kinds, gravitating, thermal, photic, rotating and revolving. Continual shiftings of position may, perhaps, continually restore to cosmical centres a reactionary *vis viva* which is exactly equivalent to their active radiations.

332. *Hirn's Hypothesis.*

G. A. Hirn (*Comptes Rendus*, Nov. 6, 1882), agrees with Faye in believing that astronomers need an absolute vacuum of matter in order to assure the stability of cosmical movements. He thinks that the doctrine must be discarded which excludes from the physical universe everything but matter and motion, and refers approvingly to Newton's letter to Bentley, implying the necessity of a constant spiritual activity, which cannot be subjected to any materialistic formulation. Seven years ago (*Proc. Am. Phil. Soc.*, xiv, 611, xvi, 302) I published a number of postulates, among which were the following:

"11. Any æthereal medium through which impulses are progressively transmitted, must be material.

"12. Any medium through which impulses are transmitted instantaneously, must be devoid of inertia and, therefore, spiritual."

333. *Laplace's Principle of Periodicity.*

I have elsewhere (*Proc. Am. Phil. Soc.*, xviii, 41–3). given some illustrations of the general principle, which was established by Laplace, that the state of a system of bodies becomes periodic when the effort of primitive conditions of movement has disappeared by the action of resistances. The periodicity of solar rotation shows the action of gravitating resistance against the efforts of luminous undulation. The resistance is just as constant as the radiation, and it would be far to seek any good reason why any provision for perpetuity which may be needful should not accompany every effort and every antagonizing resistance. If spiritual intervention is taken into consideration, its action may be merely directive, because there is a theoretical instant of absolute rest when one oscillation ends and its successor begins, so that there is no material *vis viva* to be overcome.

334. *Two-Fold Nucleation in the Dense-Belt.*

Jupiter's nodal influence (Note 331), co-operating with central condensation in the dense-belt, is shown in the following additional harmonics:

1. Jupiter's semi-axis major represents Laplace's limit for its own condensing nebula, of which the nucleal limit is the locus of incipient subsidence of Mars.

κ. In tendencies to reverse condensation towards Jupiter, Earth's mean locus of subsidence is $4.1289304\rho_3$ from Jupiter's mean locus. This represents a nucleal radius for which Laplace's limit would be $6.70965\rho_3$, which is near the mean locus of Mars on the opposite side of Sun.

λ. In like reverse condensation, the mean locus of Mars, when in conjunction with Jupiter, represents a nucleal radius for which Laplace's limit would be $5.67968\rho_3$, which is near Mercury's incipient locus of subsidence.

μ. Taking Mercury's mean subsidence locus as final or unit radius, Venus represents a nucleal radius, for which Earth's projectile locus would be Laplace's limit.

The closeness of accordance is shown in the following table:

	Harmonic.	Stockwell.	Difference.	Percentage of difference.
ι	1.75789	1.73648	.02141	$1\frac{1}{4}$ per cent.
κ	1.50685	1.52368	.01683	$1\frac{1}{8}$ " "
λ	.47688	.47680	.00008	$\frac{1}{60}$ " "
μ	.93313	.93226	.00087	$\frac{1}{110}$ " "

For further evidences of nucleal and atmospheric limitations, see *Proc. Am. Phil. Soc.*, xvi, 496–505.

335. *Another Harmonic Estimate of Saturn's Mass.*

It cannot reasonably be expected, among all the different tendencies to harmonic motion, that we can immediately find all which have been operative in any given case. In view of the small amount of work which has been done in this field, such simplicity and closeness of agreement as were shown in Notes 329–31 and 334 are very encouraging. We have already found many evidences of reciprocal or retrograde action in the Neptuno-Uranian belt, of central planetary inertia in the Saturnian belt, and of Jupiter's paramount planetary influence. If we regard all of the dense belt of planets as originally belonging to the great central nucleus, Alexander's harmony, $m_5 \rho_5^2 \doteq m_6 \rho_6^2$, may be thus modified:

Jupiter	=	Sun	÷	1047.879	= .0009543087
Earth	=	"	÷	331776	= .0000030141
Venus	=	"	÷	427630	= .0000023385
Mars	=	"	÷	3093500	= .0000003233
Mercury	=	"	÷	4865731	= .0000002055
Moon	=	Earth	÷	81.2	= .0000000371
Amount	=	Σ_m			= .0009602272

Log. Σ_m $\bar{4}.9823740$

" $(\rho_6 \div \rho_5)^2$ .5265244

Log. m_6 $\bar{4}.4558496$

m_6 = .0002856601

$m_5 \div m_6$ = 3500.67

336. *Mean Harmonic Estimate of Saturn's Mass.*

We have seen in Note 326, that in some harmonic approximations the most satisfactory results are reached, as in the foregoing note, by adding satellite or subordinate masses to their primaries, while in other cases it seems best to consider the primary mass alone. The choice of methods, in any instance, may be governed by considerations of static or kinetic equilibrium, instantaneous or progressive action, primitive or subsequent conditions, or other relations which may be unfolded by a more minute study of harmonic astronomy. If we substitute the rotary estimate of Note 313, ($m_0 \div m_3 = 330463$) in Note 335, we get $m_0 \div m_6 = 3500.62$. Combining this value with the two which are given in Note 314, we find an *exact* mean accordance with Bessel's estimate, as follows:

From central primitive nucleation,	3500.62
" " final "	3522.33
" nucleation, condensation, nebulosity and inertia,	3481.86
Arithmetical Mean,	3501.60

337. *Inner Limit of Saturn's Preponderating Influence.*

The two foregoing notes regard all the intra-asteroidal planets as in some sense satellites of Jupiter, which have been made planetary by the superior attraction of the Sun, somewhat as our Moon is both a solar planet and a terrestrial satellite. It may be asked whether Saturn's attraction when in opposition to Jupiter, is not sufficient to invalidate this hypothesis. Jupiter's mass being 3.3415 times as great as Saturn's, the extent of its equal gravitating disturbance is $\sqrt{3.3415} = 1.828$ times as great. Saturn's relative disturbance of intra-Jovian matter is greatest when Saturn is at secular perihelion ($8.734451\rho_3$) and Jupiter is in opposition, at secular aphelion ($5.519271\rho_3$). The limit of equal attraction is then at $\frac{1}{1}\frac{8}{2}\frac{2}{3}$ of $14.253722\rho_3 = 9.2134\rho_3$ from Jupiter, or $3.6941\rho_3$ from Sun, on the side towards Saturn, so that it includes all the orbits of the dense planets, and nearly all of the asteroidal belt. This fact gives new meaning to Notes 330 and 334.

338. *More About Comet Wells.*

Notes 295 and 302 illustrate the probable formation of spectral bands by the combination of different harmonic tendencies, as well as the precision of delicate measurements by a skillful observer and accuracy of judgment in estimating the centres of maximum brilliancy. It is, therefore, not unlikely that careful study may discover successive evidences of phyllotactic and other harmonic influences, as was the case in investigating atomic phyllotaxy. If we take the difference between lines a and ε in the Wells' spectrum (Note 295; 4769 — 4253 = 516), the phyllotactic numbers 2, 3, 5, 13, 34, serve in the following sub-multiples; $\frac{1}{2}$ of $\frac{2}{1^2}$ of 516 = 31.754; $3 \times 31.754 = 95.262$; $4 \times 31.754 = 127.015$; $5 \times 31.754 = 158.769$; $\frac{1}{2} \times \frac{1}{5} \times \frac{5}{1^3}$ of 516 = 134.954. These numbers give the following accordance:

	Huggins.	Harmonic.	Difference.
α	4769	4769	
β	4634	4634.046	134.954
γ	4507	4507.031	127.015
δ	4412	4411.769	95.262
ϵ	4253	4253	158.769

339. *Phyllotaxy in the Jovian System.*

The harmonies which are shown in Notes 330 and 334, supplement and help to explain the first four harmonies of Note 29 and the five harmonies of Note 14. Callisto's semi-axis major represents a phyllotactic power of a phyllotactic multiple (3^1), of Jupiter's semi-diameter. The semi-axes major of the three inner satellites are approximately connected with the nebular radius and with one another by the phyllotactic fractions $\frac{2}{3}$ and $\frac{2}{5}$, as follows:

	Harmonic.		Observed.
Nebular radius	38.45	Nebular radius	38.424
$\frac{2}{5}$ of 38.45	15.38	Ganymede	15.3503
$\frac{2}{5}$ of 15.38	9.613	Europa	9.6235
$\frac{2}{5}$ of 9.613	6.008	Io	6.0485

The greatest difference between the phyllotactic and observed loci is $\frac{3}{4}$ of one per cent.

The corresponding orbital times are connected by powers of the phyllotactic number 2.

$2^4 = 16$	Nebular radius	16.0135
$2^3 = 4$	Ganymede	4.0434
$2^1 = 2$	Europa	2.0073
$2^0 = 1$	Io	1.0000

340. *Phyllotaxy of Planetary Mass and Position.*

Peirce's phyllotaxy of orbital times (Note 135), my atomic phyllotaxy (Note 289), and my phyllotaxy of virtual areas (Note 190), encourage a search for phyllotactic relations of planetary mass and distance. Jupiter's mean projectile locus (mean perihelion), is an approximate phyllotactic basis for Saturn's mean locus of subsidence, the rupturing locus of the outer two-planet belt and the mean centre of gravity of the belt:

	Stockwell.	Phyllotactic.
Jupiter	4.978	5
Saturn	10.000	2×5
$\frac{1}{2}$ Neptune	15.017	3×5
e. g. Uranus and Neptune	25.031	5×5

If Saturn's mean perihelion were in the same longitude as that of the outer belt, the phyllotactic sum of their disturbing forces $(2 + 5)$ would become an important limit of oscillatory inertia. Simple phyllotactic com-

binations of this sum with phyllotactic powers of 2, 3, and 5 give the following mass-approximations:

	Computed.	Phyllotactic.
Sun ÷ Jupiter	1047.879	$1050 = (2+5)\ (2\times5)\ (3\times5)$
Sun ÷ Saturn	3501.6	$3500 = (2+5)\ (2\times5)^2\ (5)$
Sun ÷ Uran. and Nep.	10433	$10500 = (2+5)\ (2\times5)^2\ (3\times5)$
Sun ÷ Earth	330463	$330750 = (2+5)^2\ (2\times5)\ (3\times5)^2(3)$
Sun ÷ Venus	427240	$428400 = (2+5)\ (2^2\times5)\ (3^2\times5)\ (34)$
Sun ÷ Mars	3093500	$3094000 = (2+5)\ (2\times5)^3\ (13\times34)$
Sun ÷ Mercury	4865751	$4873050 = (2+5)^2\ (3\times5)^2\ (13\times34)$

The greatest deviation is less than $\frac{7}{10}$ of one per cent.

341. *Centripetal Harmonies of Planetary Mass and Position.*

If we begin with the outer two-planet belt, we find evidence of the following successive influences:

a. Rotary *vis viva*, $(m\rho^2 \div 2)$. (1). If we call the sum of the masses of Neptune and Uranus $m_{(7)} = m_7 + m_8$, we find that its influence of rotary perturbation introduces both the same and the diametrically opposite mean perihelion longitudes of Saturn, provided that $\rho_{(6)}$ and $\rho_{(7)}$ represent, respectively, the incipient loci of subsidence of Saturn and Uranus; $m_{(7)}\ (\rho^2_{(7)} - \rho^2_{(6)}) = m_6\rho_{(6)}^2$. (2). If we call the sum of the masses of Jupiter and the dense belt, $m_{(5)} = m_5 + m_4 + m_3 + m_2 + m_1$, we find that its mean influence of rotary perturbation is the same as that of Saturn; $m_{(5)}\rho_5{}^2 = m_6\rho_6{}^2$.

β. Rotary momentum. The interior mass of the three primitive masses, $m_{(5)}$, was so divided that Sun's semi-diameter became the rupturing locus for the principal centre of gravity of the system (c. g. of m_0 and m_5). Designating Jupiter's radius vector at secular perihelion by $\rho_{(5)}$, we find, $m_0\rho_0 = m_5\rho_{(5)}$.

γ. Photic time-integral. Sun's mass and density are so harmoniously adjusted that the oscillations of solar rotation indicate the actions and reactions of a wave-velocity which is equivalent to the velocity of light (Notes 17, etc.).

δ. Secondary time-integrals. The solar superficial gravitating acceleration, which is determined by the photic time-integral, determines in its turn the velocity of circular-orbital oscillation $(\sqrt{gr})$ at all distances from Sun's centre. The velocity at Sun's surface gives Jupiter's time-integral: the velocity at the mean centre of gravity of the system gives Earth's time-integral.

ε. The photic time-integral (*γ*), the probability that Sun's density is harmonically determined by the density of hydrogen, and the equality of æthereal and solar mass which is implied by their equality of action and reaction, give the proportion at Sun's surface,

$$\text{Modulus}^3 : \rho^3_0 : : \text{density of hydrogen} : \text{æthereal density}.$$

342. *Secondary Harmonies of Planetary Mass and Position.*

The data of the foregoing note are sufficient for approximate determinations of the respective masses at the chief centres of nucleation, condensation, nebulosity, and rotary planetary inertia, (Sun, Earth, Jupiter and Saturn). The division of the outer two-planet belt, and the separation of Venus from the primitive interior belt were determined by simple relations of vector-radii, which may be regarded as indicative either of photodynamic time or photodynamic *vis viva*.

ζ. The radii which determined the aphelion and perihelion masses of the outer belt were, respectively, the aphelion and perihelion loci, or the loci of incipient subsidence and incipient projection, at the inner limit of the belt (Note 315).

η. The radii which determined the relative masses of Earth and Venus were, respectively, the mean radius-vector and the locus of incipient subsidence of the respective planets (Note 313).

343. *Centripetal Approximations*

If we take the phyllotactic estimates of Mercury and Mars (Note 340), with the gravitating or centripetal estimates of the other planets, and of solar and æthereal density (Notes 341-2), we find the following approximations, which may be compared with those of Notes 325 and 328:

	Harmonic.	Computed.	Difference.
Sun ÷ Mercury,	4873050	4865751	$\frac{3}{20}$ of one per cent.
Sun ÷ Venus,	426721	427240	$\frac{1}{8}$ " "
Sun ÷ Earth,	330463	331776	$\frac{2}{5}$ " "
Sun ÷ Mars,	3094000	3093500	$\frac{1}{61}$ " "
Sun ÷ Jupiter,	1047.879	1047.879	
Sun ÷ Saturn,	3500.69	3501.6	$\frac{1}{38}$ " "
Sun ÷ Uranus,	22759	22600	$\frac{7}{10}$ " "
Sun ÷ Neptune,	19467	19380	$\frac{13}{29}$ " "

Density of Sun ÷ Earth .25493	Log. = T.4064086
Density of Æther ÷ Hydrogen 106,939,960,000,000,000	17.0291400
Solar Modulus of light, $474657\rho_0 = 2213.37\rho_3$	3.3450539
Solar Rotation, 25.5064 days	1.4166487
Orbital time at ρ_0, 10049 seconds	4.0021223
Sun's semi-diameter, ρ_0, 432089 miles	5.6353735
Earth's semi-axis major, ρ_3, 92,661.550 miles	7.9668996

344. *Laplace, Herschel and Fourier.*

Laplace's statement of the nebular hypothesis has been generally thought to imply that the planets and satellites were thrown off by the centrifugal force of contracting nuclei. Many objections have been found to this hypothesis, of which the moons of Mars furnish a striking example. Herschel's theory of subsidence, by recognizing the equality of action and reaction, removed these objections, provided for the recognition of

cometary and meteoric influences, and made the moons of Mars, as I have shown (*Proc. Am. Phil. Soc.*, xvii, 302), an unexpected confirmation of his views. Fourier's discussions of elasticity and cyclical motion, in a line of research to which American investigators have made important contributions (see *op. cit.*, xvi, 298–302), showed that all cyclical movements are *quasi*-elastic and may be represented by simple combinations of elastic formulæ, and thus paved the way for a wide extension of the theory of harmonic motion. The three foregoing notes show a combination of simultaneous and continuous activities, which it would be difficult, if not impossible, to explain by Laplace's theory. They are all, however, in full accordance with the views of Herschel and Fourier, and they indicate that the photic æther may still be regarded as nebulous.

345. *Photic Loci of Earth and Saturn.*

Note 341 suggests the influence of linear oscillation in subsiding particles. Neptune's locus of incipient subsidence ($30.47\rho_3$) became, by the relative slowness of its motion, a point of virtual suspension. Saturn's locus of incipient subsidence ($10.343\rho_3$) which was near its centre of oscillation ($10.16\rho_3$), was the origin of the belt of mean planetary inertia. While the Neptuno-Uranian and the Jupiter-Telluric belts were yet undivided, the theoretical period of rotation was $(30.46955 \times 214.45)^2 \times 25.5064\text{dy} = 3050950.7$ years. The fundamental photodynamic equation (Note 321), with the equality of action and reaction, fixed the chief centre of condensation at a locus which is in simple photic relations with the solar nucleus, the photic radius of rotation and the centre of planetary rotating inertia. For the mean proportional between the mean locus of incipient planetary subsidence ($10.343253\rho_3$) and Earth's semi-axis major is $3.2161\rho_3 = 689.69\rho_\circ$. If we call this the photic radius, or the locus of luminous equatorial velocity for a sphere which would have orbital velocity at Sun's surface, Earth's semi-axis major should be $[31558149 \div (2\pi \times 497.827 \times 689.69)]^2\rho_\circ = 213.99\rho_\circ$, which is within $\frac{4}{10}$ of one per cent. of the British Nautical Almanac estimate ($214.45\rho_\circ$).

346. *Mass-Relations of Earth and Saturn.*

The relative masses, as well as the relative positions, of the chief centres of condensation and of planetary inertia, show simple harmonic accordances with the energies of æthereal rotation and reacting inertia; Earth's locus of incipient projection ($.932265\rho_3$), bearing the same ratio to Saturn's mean locus of projection ($9.077645\rho_3$), as the square root of Earth's mass bears to the square root of Saturn's mass, thus indicating an exact equivalent between the moment of rotation and the inertia of mass. This gives $331988m_3 = m_\circ$; $\rho_3 = 92{,}805{,}400$ miles. The mass-value differs by less than $\frac{1}{3}$ of one per cent. from the value which was adduced from the relative inertia of Earth and Jupiter (Note 152), and by less than $\frac{1}{15}$ of one per cent. from the value which was deduced from centres of oscillation (Notes 5, 23).

347. *Phyllotaxy of Orbital Periods.*

The closeness of the phyllotactic mass-harmonies (Note 340), may be more strikingly shown by observing the discrepancies in Peirce's approximations to the orbital periods of the primary planets, which seem to have been the first extensions of the phyllotactic theory beyond the vegetable world :

	Phyllotactic.		Observed.	Difference.
		Neptune	60126.72	
$\frac{1}{2}$ Neptune	30063.36	Uranus	30686.82	$2\frac{1}{14}$ per cent.
$\frac{1}{4}$ Uranus	10228.94	Saturn .	10759.22	$5\frac{2}{17}$ "
$\frac{2}{5}$ Saturn	4303.69	Jupiter	4332.58	$\frac{2}{3}$ "
$\frac{2}{5}$ Jupiter	1733.03	Asteroid 139	1723.37	$\frac{5}{9}$ "
$\frac{2}{5}$ Asteroid 139	689.35	Mars	686.98	$\frac{1}{3}$ "
$\frac{1}{2}$ Mars	343.49	Earth	365.26	$6\frac{1}{3}$ "
$\frac{5}{13}$ Earth	224.78	Venus	224.70	$\frac{1}{23}$ "
$\frac{2}{5}$ Venus	89.88	Mercury	87.97	$2\frac{1}{3}$ "

The greatest deviation is more than nine times as great, and the mean deviation is more than ten times as great as in Note 340.

348. *Photic Relations of Earth, Jupiter, and Asteroid 139.*

In view of the many evidences of the important influence of Jupiter upon planetary harmonies, the following proportion becomes suggestive :

$$t_\alpha : t_\beta :: \rho_\lambda : \rho_\odot$$

The second theoretical phyllotactic reduction of Jupiter's orbital period, $\frac{2}{5}$ Asteroid 139, is represented by t_α ; Earth's day, by t_β ; the photic radius (Note 345), by ρ_λ ; Sun's semi-diameter, by $\rho_\odot$. The value of ρ_λ, as deduced from this proportion, is $214.2\rho_\odot$, which is about $\frac{2}{17}$ of one per cent. less than the British Nautical Almanac estimate. This is only $\frac{1}{156}$ as great as the mean accidental deviation (Note 288).

349. *Modifications of Harmonic Planetary Masses.*

The approximations of Note 342 are more closely connected than those of Note 328, and indicate a simpler bond of harmony. Among the various harmonic influences which may be presumed to have modified planetary masses and to be represented in their harmonic motions, are the following : (1). The fundamental velocity of Note 321, which was first indicated by my barometric investigations (*Proc. Am Phil. Soc.*, ix, 283–8). (2). Centres of linear, spherical and explosive oscillation (*Ib.*, xii, 392–4, 411–7 ; *et al.*). (3). The acquisition of nebula-rupturing velocities, by subsidence from nr to $\frac{nr}{n+1}$ (*Ib.* xii, 518–22). (4). Tendency to rupture in the periphery of a stationary nebula, at $2r \div (3 - \sqrt{8})$ (*Ib.* xvii, 98–99). (5). Belt-forming tendencies, through subsidence, at $\frac{2r}{3}$ (*Ib.*, xvii, 100*). (6). The

* Instead of "minor axis of $\sqrt{8}r$" *read* "minor axis of $\sqrt{2}r$."

ratio of the circumference of a circle to its diameter (*Ib.*, xiii, 140–1, xiv, 609–12, *et al.*). (7). Time integrals, rotation-waves, harmonic vibrations, polar forces, etc. (*Ib.* xiv, 141–7). (8). Laplace's limit, and its variation as the $\frac{4}{3}$ power of the nucleal radius (*Ib.*, xiv, 612, 622, 632, *et al.*). (9). Constancy of pressure and constancy of volume (*Ib.*, xiv, 651). (10). Instantaneous velocity, implying spiritual influence (*Ib.*, xiv, 611; xvi, 302, *et al.*). (11). Comparative variations of distance and density, in elastic media (*Ib.*, xvii, 109–12, *et al.*).

350. *Relation of Inertia to Time and Force of Oscillation.*

M. Lipschitz, in a letter to M. Hermite (*Comptes Rendus*, xcv, 1141), discusses some points which have an important bearing on my fundamental equation (Note 321), and on time-integrals in general. Supposing a heavy body to turn freely about a horizontal axis, he considers two kinds of movement. In the first, the angular velocity becomes 0 at θ_0; in the second, at $\pi - \theta_0$. The times in the two movements may be expressed by elliptic integrals of the first order, with complementary moduli. The corresponding integrals of the second order represent Hamilton's *accumulated vis viva*, or the integral of which the element is equivalent to the sum of all the living forces of the system multiplied by the element of the time. The result of the discussion, which he considers remarkable, gives an equation of oscillating times and accumulated *vis viva*, for the two kinds of movement, which depends solely on the moment of inertia of the body.

351. *Motion of Sun-Spots in Latitude.*

Spœrer, in a letter to Faye (*Comptes Rendus*, xcv, 1110), reports observations upon the movement of Sun-spots in latitude. Arranging the observations of twenty years (1861–80) in 5° belts, he finds a slight excess of movement towards the equator between the parallels of 5° and 10°, and a slight excess towards the poles between the parallels of 20° and 25°. Carrington and de Rico found a predominance towards the equator between 0° and 15°, and towards the poles in higher latitudes, but the indications were so slight that Carrington attached no importance to them. Faye regards these results as fatal to the theory of Siemens, for if the Sun is fed by the subsidence of matter towards the poles, he thinks that the equatorial centrifugal force should produce a constant tendency of spots towards the equator. He also calls attention to the fact that the centripetal force at Sun's equatorial surface $\left(\frac{gr}{\vartheta_0} \div v^2_{\text{rot}}\right)$ is about 48000 times as great as the centrifugal, and he attributes the equatorial increase in apparent velocity of rotation to the continual convection-currents between the photosphere and the interior of the Sun.

352. *Photodynamic Centrifugal Energy.*

At the very outset of my planetary investigations I called attention to the accelerating effects of "subsidence," and Hall's discovery of the moons of Mars strengthened my conviction that such acceleration was the

vera causa of Sun's equatorial acceleration. Jupiter's influence upon harmonic masses and positions (Notes 313, etc.), and the close approximation of the photic radius (Note 345) to Jupiter's projectile centre of linear oscillation, show that there are activities, at various distances from the Sun, which should be considered in discussing the conservation of solar energy. The centrifugal force to which Siemens refers is by no means limited to Sun's surface; at Laplace's limit ($36.36r_\odot$), at the photic radius ($689r_\odot$), and at the solar modulus of light ($689^2r_\odot$), there are important rotating and consequent centrifugal tendencies which have been almost wholly overlooked. Darwin's discussions of terrestrial "viscosity" furnish many suggestive hints for an investigation which, as I fully believe, will help greatly to extend Laplace's views of universal stability. No one, probably, would think of limiting the centrifugal force of terrestrial rotation to Earth's surface, nor even to its atmospheric modulus; there is great likelihood that an appreciable atmosphere may extend even beyond Laplace's limit ($6.6r_\oplus$), all portions within that limit rotating synchronously with Earth, while all portions beyond the limit are subject to combined influences of rotation and revolution. Sun's æthereal modulus extends to more than 73 times Neptune's semi-axis major, and if we suppose that to be the limit of æthereal centrifugal tendency, we have an available velocity which is 689 times as great as the velocity of light, If we suppose, still further, that Laplace's velocity of gravitating action, more than $100{,}000{,}000v_\lambda$ (*Mec. Celeste*, X, vii, 22), represents an actual physical velocity, we have a radius of rotating influence which extends from the Sun as a centre to more than 13000 times the distance of α Centauri.

353. *Motion in Perfect Fluids.*

Siemens calls attention (*Comptes Rendus*, xcv, 1040), to the results of Froude's Torquay experiments, which showed that a submerged body, moving with uniform velocity in a perfect fluid, will meet no resistance whatever. By "a perfect fluid" is meant a fluid free from viscosity or *quasi* solidity, and in which no friction is caused by the slipping of its particles either over one another or over the surface of the body. If there are any such fluids, the luminiferous æther is doubtless one. Ferrel's investigations have shown that the centrifugal force of rotation would draw it entirely away from the poles, so that more viscous fluids, such as our atmosphere, would serve, as Siemens says, as lubricators, to supply temporary vacua which would otherwise result from the slight lateral elastic oscillations of the æther. These considerations, as well as those of the foregoing note, open a new field for analytical research, which must be thoroughly explored before final judgment can be passed upon questions pertaining to the conservation of solar energy, the stability of the physical universe, and the reproach of thermodynamics.

354. *Centripetal Transformation of Radiations.*

When particles or bodies are moving in circular orbits, under the influence of central forces, the centripetal and centrifugal forces are in equi-

librium; in parabolic orbits, the centripetal *vis viva* is twice as great as the centrifugal on approaching the centre, and one-half as great on receding from the centre; in elliptical orbits, the ratio of the living forces varies inversely as the ratio of the radius-vector to the semi-axis major. In actual orbital motions, the alternate oscillations between the apsides are equal, but in opposite directions. This must be true of the æther, as well as of planets and satellites, if the æther has any orbital motion, and reasoning from analogy we might fairly suppose that it is true of æthereal waves. What becomes of the heat which is supposed to be absorbed by the æther? Does it increase the mean distance of the æthereal particles, does it maintain an ever increasing amount of æthereal undulation, or is it resolved into some form of gravitating or other centripetal activity, which furnishes conclusive evidence of the universality of the law that "action and reaction are equal and in opposite directions?" A single fact is worth more than a million theories, however plausible they may be. The second law of thermodynamics is purely theoretical, inasmuch as it tries to account for activities which are beyond the reach of experimental investigation. The fundamental equality of Note 321 is a significant and far-reaching FACT, which illustrates Laplace's principle of periodicity (Note 333), and bears satisfactory witness to the continuance of activities which have hitherto been the reproach of thermodynamics.

355. *Primitive Photodynamic Locus of Neptune.*

The combined influence of the tendencies to rotation and revolution (Notes 348, 332, etc.), is shown in the outer limits, as well as at the centre of the planetary system. The outer extremity of the photic radius (Note 345), has an oscillatory trajectory which is $(\pi v_\lambda \div v_\circ)$ times as great as that of $\rho_\circ$. Its rotatory *vis viva*, and consequently, its radius of relative projection, is $(\pi v_\lambda \div v_\circ)^2$ times as great, and the orbital period of this projectile radius is $(\pi v_\lambda \div v_\circ)^3 \times 2\pi \sqrt{(r_\circ \div g_\circ)}$. Jupiter's secular eccentricity, according to Stockwell, is .0608274. This gives, for the linear centre of oscillation of its locus of incipient subsidence, .0405516, and for the solar radius vector of that centre, 1.0405516. If we take a like projection of Neptune's locus of incipient subsidence ($1.0405516 \times 30.46935 = 31.70514$) as an original nucleal radius (ρ_ν) for which Laplace's limit (ρ_λ) was $(\pi v_\lambda \div v_\circ)^2 \rho_\circ$, we find $\rho_s = (\pi^2 v_\lambda \rho_s \div v_s \rho_\nu)^{\frac{2}{3}} \rho_\circ$; $v_\lambda \div v_s = 31558149$ sec. $\div (2\pi \times 497.827 \text{ sec.}) = 10089.116$; $\rho_s = 214.461\ \rho_\circ$; $\rho_\nu = 6799.52\ \rho_\circ$; $\rho_\lambda = 4684434\ \rho_\circ$.

356. *Primitive Photodynamic Locus of Saturn.*

The value of Sun's apparent semi-diameter as deduced from the foregoing note is $206264.''806247 \div 214.461 = 961.''78$, the British Nautical Almanac estimate being $961.''82$. A mean proportional between Sun's semi-diameter and ρ_λ ($2164.36\ \rho_\circ = 10.09206\ \rho_s$) is within less than one per cent. of Saturn's mean subsidence locus ($10.000059\ \rho_s$). The photic

radius ($\rho_\phi = \rho_\circ v_\lambda \div v_\circ = 688.936\ \rho_\circ$) is a mean proportional between Earth's semi axis major and Saturn's incipient subsidence locus ($2218.23\ \rho_\circ = 10.343253\ \rho_3$) within less than $\frac{1}{8}$ of one per cent. A mean proportional between ρ_ϕ and ρ_ν is also a mean proportional between $\rho_\circ$ and ρ_λ. Hence we see that Sun's radius, Earth's radius-vector, the photic radius, as well as the original nucleal and limiting radii of the system, are all represented through their harmonic influences upon the belt of mean planetary inertia.

357. *Stellar Relations of Primitive Photodynamic Loci.*

In whatever way we may regard these many indications of harmonic influence upon planetary positions and orbital periods, whether as furnishing evidence of early nebular condensation or of nebular activities which still continue, we can hardly believe that they are confined to our immediate system. The nearest companion system being that of *a Centauri*, we need feel no surprise at finding that ρ_ν is a mean proportional between Sun's radius and the distance of *a Centauri*, and ρ_λ is a mean proportional between the solar modulus of light and the distance of *a Centauri*. The distance which is thus indicated differs by less than $\frac{1}{4}$ of one per cent. from the one which was deduced from the corona line and the masses of Earth and Jupiter (Note 46). The photic radius is, of course, a mean proportional between Sun's radius and the solar modulus of light.

358. *Photodynamic Relations of the Neptunian System.*

Stockwell (*Wash. Obs.*, for 1873, App. I), deduced two values for the quotient of Sun's mass by Neptune's mass, viz.: 19700 from perturbations of Uranus, and 19380 ± 70 from Neptune's satellite. The former value may, perhaps, indicate the mass of the planet; the latter, the mass of the Neptunian system, including the satellite which has already been discovered, together with any others which may be yet unknown, and one or more possible remote planets. The orbital period of the primitive projectile radius (Note 335) is 19613.1 times Neptune's orbital period. Designating these periods by $t_\circ$ and t_3, respectively, we have the approximate harmonic proportion,

$$t_\circ : t_3 :: 19613.1 : 1 :: m_\circ : m_3.$$

This value is intermediate between Stockwell's two estimates, differing but $\frac{3}{8}$ of one per cent. from their mean, but $1\frac{1}{3}$ per cent. from the smaller and but $\frac{1}{3}$ of one per cent. from the larger estimate. As the proportion is based upon time-integrals which must be operative, this closeness of accordances is interesting.

359. *Phyllotactic Relations of Earth and Neptune.*

To the harmonic relations which I have already pointed out, between the planetary masses at the centre of incipient subsidence (Neptune) and at the chief centre of nucleation, may be added a very simple phyllotactic relation, which is shown by the proportion,

$$m_3 : m_3 :: 2 : 34.$$

If we take the mass-estimate of Note 313, $m_0 \div m_3 = 330463$, this proportion gives $m_0 \div m_8 = 19439$, which is, within the limits of probable error, in accordance with Stockwell's second estimate. The interest of this harmony is increased by the fact that the ratio of Earth's equatorial velocity of rotation is to the limiting value of $\sqrt{g_3 r_3}$ in the same phyllotactic ratio of 2 to 34.

360. *Harmonic Relations of Saturn, Mars, and the Telluric System.*

The harmonic actions and reactions among the masses at the centre of planetary inertia (Saturn), the centre of incipient subsidence for the belt of greatest condensation (Mars), and the central system in the belt of greatest condensation (Earth and Moon), is shown by the proportion

$$m_6 : \pi\, m_{(3)} :: \pi\, m_{(3)} : m_4.$$

Taking Bessel's estimate, $m_0 \div m_6 = 3501.6$, with the rotary estimates of Notes 313 and 316, $m_0 \div m_3 = 330463$, $m_3 \div \mu = 81.08$, this proportion gives $m_0 \div m_4 = 3083416$, which differs by less than $\frac{1}{4}$ of one per cent. from Hall's estimate. These repeated harmonic relations of mass seem to show that every planet represents some special central tendency, and when that tendency is found, the harmonic calculus will furnish estimates which are generally closer than those which have been reached by the ordinary astronomical methods. If this is the case with the first approximations, we may well hope that a due regard to secondary and subordinate harmonies will give results of a very satisfactory character. In the present instance, if we regard Hall's estimate as correct, and deduce the value of Earth's mass, we find $m_0 \div m_3 = 331003$, which is within the limits of probable error.

361. *Synoptic Table.*

The six foregoing notes are, in some respects, more comprehensive in their harmonic indications than any that have preceded them. I therefore give the following comparative table:

	Harmonic Logarithms.	Anti-logs.	$n\,\rho_3$
ρ_3	2.3313488	214.461	1.
ρ_ϕ	2.8381787	688.936	3.2124
ρ_4	3.3353286	2164.356	10.0921
ρ_ν	3.8324785	6799.523	31.7051
M	5.6763574	474632.	2213.1381
ρ_λ	6.6706572	4684435.	21842.8
a Cent.	7.6649570	46233521.	215579.8
$v_0 \div v_\nu$	2.3410288	219.295	
t_0	4.0020883	10048.2 sec.	
t_ν at ρ_0	6.3431171	2203520.3 sec.	
t_ν at ρ_0	1.4066034	25.504 days.	
$\delta_0 \div \delta_3$	T.4064550	.25495	

362. *The Terrestrial Series.*

The above table introduces two geometrical series; the first having the ratio π, and having for one of its terms a solar radius-vector for Earth, similar to the one for Jupiter in Note 355 ($1 + \frac{2}{3}\,\varepsilon_3 = 1.02358$).

Harmonic.			Observed.
a	.32548	Mercury, mean perihelion,	.31873
$\pi\ a$	1.02254	Earth, l. c. o. of sec. ecc'y,	1.02258
$\pi^3\ a$	3.21240	Photic radius, ρ_ϕ,	3.21240
$\pi^5\ a$	10.09201	Saturn, mean aphelion,	10.00006
$\pi^4\ a$	31.70514	Neptune, ρ_ν,	31.70514
$\pi^5\ a$	99.60465	Forbes, I, Note 32,	100.
$\pi^6\ a$	312.91727	Forbes, II, Note 32,	300.

This series includes the inner and outer principal planets, the centers of planetary inertia and of maximum condensation, the photic radius, and the two supra-Neptunian belts of cometary aphelia. The planetary loci are those of my first anticipatory series (*Proc. Amer. Phil. Soc.*, xiii, 140), with such modifications as represent the photic radius and the linear centers of oscillation of Earth and Jupiter. Each of the two-planet belts is indicated, and the photic radius precisely marks the locus of Asteroid 108. It also differs by less than $\frac{1}{8}$ of one per cent. from a mean proportional between Earth's semi-axis major and Saturn's locus of incipient subsidence ($3.21609\ \rho_3$).

363. *The Stellar-Photic Series.*

The second geometrical series of Notes 355–61, has the ratio π^2 and has, for two of its terms, a stellar locus and the solar modulus of light.

Harmonic.			Observed.
β	.00239	.5135 Sun's semi-diameter,	.00239
$\pi^2\ \beta$	.02363	5.0683 Sun's semi-diameter,	.02363
$\pi^4\ \beta$	.02324	$\frac{1}{2}$ Mercury's sec. aph.,	.23840
$\pi^6\ \beta$	2.30202	Mean prop. Jupiter and Earth,	2.28096
$\pi^8\ \beta$	22.72004	$\frac{3}{4}$ Neptune's mean aph.,	22.75153
$\pi^{10}\ \beta$	224.2378		. . .
$\pi^{12}\ \beta$	2213.1381	Solar modulus of light,	2213.1381
$\pi^{14}\ \beta$	21842.804	Photic projectile radius,	21842.804
$\pi^{16}\ \beta$	215579.86	*a Centauri*,	215579.86

The planetary indications are not quite so satisfactory as in the foregoing series, but the deviations are of the same order of magnitude as planetary eccentricities. Neptune's mean subsidence locus indicates a solar nebular density corresponding to Laplace's limit, for a rotating nucleus with a semi-diameter equivalent to $\pi_8\beta$. Mercury's primitive subsidence-locus indicates a degree of "viscosity" which would give a rupturing tendency at a mean proportionate locus between Sun's viscous rupturing locus and $\pi_8\beta$. The mean proportional between these two loci is also a mean proportional between Earth's primitive subsidence-locus and Jupiter's mean projectile-locus. The deviations from exact accordance, according to

Stockwell, are respectively, $\frac{1}{7}$ of one per cent., $\frac{1}{46}$ of one per cent. and $\frac{2}{15}$ of one per cent. The three terms which indicate mere photodynamic progression show an exact accordance; but there is a range of uncertainty which is of the same order of magnitude as planetary eccentricities, with regard to the exactness with which the third of those terms represents the locus of *α Centauri*. The harmonic term preceding the solar modulus is 7.466 times Neptune's semi-axis major. It has no obvious known representative, but future researches or discoveries may make it significant. The Terrestrial and the Stellar-Photic series are connected by the proportion:

$$\alpha : \beta :: \pi^{19} \rho_\odot : \rho_\phi :: \pi^{19} v_\odot : v_\lambda.$$

These several relations confirm the views which were expressed in Note 262.

364. *Photodynamic Subsidence-Relation of Earth and Jupiter.*

The photodynamic projections of β from Sun's rupturing locus, of the chief centre of gravity (Sun and Jupiter) from Sun's surface, of the centre of the dense belt from the chief centre of condensation, and of ρ_ν from Neptune's locus of incipient subsidence, seem partly to account for the photodynamic gravitating relations of Earth's day and year. The radius vector of the viscous rupturing locus of Jupiter's incipient subsidence (Note 355) is 1.0304137. If $t_3 = 1$ year, we have, very nearly if not exactly, the equations:

$$g_3 t_3 = 1.0304137\, v_\lambda.$$
$$v_\lambda = 186125.8 \text{ miles}.$$
$$\rho_3 = 92{,}639{,}000 \text{ miles}.$$
$$m_\odot = 330{,}419\, m_3.$$

365. *Conservative Momentum of Vis Viva.*

Whether we accept or reject the hypothesis of Lesage, as a literal explanation of gravitating action, it may serve as a convenient concept for representing activities which are obviously incessant. There are constant centripetal tendencies towards the Sun, as well as constant radiations from the Sun, each varying inversely as the square of the distance, and each subject to the law of equality between action and reaction. Lesage supposed that they were opposite phases of a single energy, and his views are favored by the law of parsimony. If we reject them altogether, our perplexity is doubled, for we have two reactions to account for, instead of one. Even Newton, Peirce and Helmholtz; the first, in his hypothesis of an "æthereal spirit," the others in seeking an equivalent between solar radiation and solar contraction; were guided, though less directly, by the law of action and reaction. In circular orbital motion, centripetal gravitation continually deflects the tangential path, so as to make it π times as long as the radial path before the tangential oscillation reverses its direction. The influence of momentum in such a change is represented by the terrestrial series (Note 362); the influence of *vis viva*, in the stellar-

photic series (Note 363); the influence of both, in the fundamental equality (Note 321). If there is neither waste nor accumulation of energy, and if there is a material æther, the hypothesis that the centrifugal action of every æthereal radiation is followed by an equal and opposite centripetal reaction, and *vice versa*, is justified by all the known phenomena of the heavenly bodies.

366. *Dynamics and Kinematics.*

William B. Taylor delivered an address on "Physics and Occult Qualities," before the Philosophical Society of Washington, Dec. 2, 1882, on retiring from the Presidency of the Society. He discusses with great skill and lucidity, the comparative views of the kinematists who hope in time to resolve all physical enigmas by molecular processes, and of the dynamists who, "having searched in vain for any plausible co-ordination of the indisputable facts of cohesion [and other material phenomena] with an intelligible mechanical agency, simply acquiesce in the result, and without invoking the unknown or the irrelevant, accept this established property as ultimate and inexplicable." In one paragraph (p. 30) he says: "Without the indestructible—unwasting—tensions of molecular attraction and repulsion, it lies beyond the scope of human ingenuity to devise or imagine a conservative system," thus corroborating views which I have been advocating for twenty years. In another (p. 48), he seems to be somewhat self-contradictory, in saying: "*Under the present system of dynamic law*, it is certain that as radiating and cooling bodies,

> 'The Stars shall fade away, the Sun himself
> Grow dim with age, and nature sink in years.'

Nor is there known to science any natural process whereby this cosmic doom may be either averted or repaired by ulterior reversal." This is true of kinematics, but dynamic law positing behind itself "an Infinite LAWGIVER," need give no thought to kinematic perplexities and paradoxes. Force "is attended with no expenditure and is capable of no exhaustion" (p. 30). In his reference (p. 27) to the experiments of Guthrie and Bjerknes, on attractions or repulsions by mechanical vibration, he has overlooked my own experiments, which were published more than six years before Guthrie's (*Proc. Amer. Phil. Soc.*, ix, 359; x, 151–66). In his antagonism of the doctrine of "unity of force" (p. 45), he makes no reference to the identification of velocity, in the most important known manifestations of photic, electrical, gravitating and thermal activity, as shown in the fundamental equality (Note 321).

367. *Anticyclonic Storms.*

Loomis, in his 18th Contribution to Meteorolgy (*Am. Jour. Sci.*, Jan., 1881), gives many illustrations of the frequency of anticyclonic storms, to which I called attention in 1871 (*Proc. Am. Phil. Soc.*, xii, 40). My views were afterwards adopted in the Signal Service "Suggestions as to the practical uses of Meteorological Reports and Weather Maps," in magazine and

newspaper articles by S. S. observers, and in reports of the Chief Signal Officer. Prof. Loomis is, perhaps, somewhat unconsciously biased by a still lurking prejudice in favor of Redfield's views, which disposes him to trace all rainfalls to "a cyclonic movement of the winds about the rain area." As soon as the rain begins to fall, there must undoubtedly be a local cyclonism, as I stated (*loc. cit.*, 7); but a careful study of weather-maps, especially in winter storms and in cases of failing forecasts, satisfies me that the *origin* of storms is as much anticyclonic as cyclonic. The frequent instances of snows in a "high" area, with simultaneous rains in a "low" area, are very instructive. Ferrel's researches show that cyclonism and anticyclonism must be companions. It is, therefore, hardly right to regard either as peculiarly storm-breeding. The *vera causa* is a blending of moist and cold currents. When the precipitation begins in a high area, the initial currents are anticyclonic; when in a low area, cyclonic. Ferrel's middle-latitude ridge of high barometer also explains the anticyclonism of our Southern States, to which Loomis refers.

368. *"Central Forces and the Conservation of Energy."*

Mr. Walter R. Browne (*Phil. Mag.*, Jan. 1883), confirms some of the views of central force which have guided my own researches, and which are embodied in Taylor's retiring address (Note 366). He shows that the conservation of energy requires, and results from the equation

$$\int_a^{a+b} \mathrm{F}\, dx = \int_{a+b}^{a} \mathrm{F}\, dx;$$

in which two particles, A and B, are alternately receding and approaching between the distances a and $a+b$; and that F can only be a function of r; "in other words, the force with which A acts upon B always tends towards A, and varies, if it varies at all, according to the distance from A only. But this is the definition of a central force." He also refers to his paper "On Action at a distance" (*Phys. Soc.*, 1881; *Phil.. Mag.*, Dec., 1880), in which he showed that it is "impossible to explain certain elementary facts of physics without the hypothesis of action at a distance." He deduces from the kinetic theory of gases, the conclusion that the collision "occasions the instantaneous development of a strictly infinite force." In 1876, I showed that "if the theory of Boscovich were true, at the centre, where $\rho = 0$, v_ρ would be infinite" (*Proc. Amer. Phil. Soc.*, xvi, 304). These conclusions, as well as Laplace's doctrine of the instantaneous action of gravity (*op. cit.* p. 302), are inexplicable by any hypothesis which does not either recognize spiritual activity or spiritualize its definition of matter.

369. *Mean Molecular Excursions.*

In discussing the kinetic interpretation of the law of gases, Taylor cites (*Address* p. 17) the application of the calculus of probabilities, by which Clausius inferred "that of the whole number of free molecular excursions in a given time (in any large enclosure), those having less than the mean length will be 0.6321, or nearly double the number of those having

the mean length or exceeding it. The simplicity of thermodynamic relations in central force (*Proc. Amer. Phil. Soc.*, xiv, 651), suggests an equally simple means of estimating the proportionate number of mean excursions. Peirce's views respecting the *vis viva* of rotation (see *Proc. Amer. Phil. Soc.*, xvi, 300), involve the consideration of the mean moment of inertia, which is represented by $\frac{2\,r^2}{5}$, the momentum being represented by $r\,\sqrt{\frac{1}{4}} = .632455\ r$, which differs from the estimate of Clausius by less than $\frac{1}{17}$ of one per cent.

370. *Cosmical Influence of Rotary Inertia.*

We may naturally suppose that, among the many harmonic influences which have combined in fixing the relative positions of the several planets, rotary inertia should be represented Among the evidences which strengthen such a supposition, are the following:

2.5 Mercury, sec. per.,	.7435	Venus, mean aph.,	.7489
1.5 Mercury, mean per.,	.4781	Mercury, s. a.,	.4768
2.5 Mercury, mean,	.9677	Earth, m. p.,	.9661
1.5 Mercury, m. a.,	.6832	Venus, s. p.,	.6722
1.5 Mercury, s. a.,	.7152	Venus, mean,	.7232
1.5 Venus, s. p.,	1.0084	Earth, mean,	1.0000
1.5 Earth, s. p.,	1.3984	Mars, m. p.,	1.4032
2.5 Jupiter, s. p.,	12.2158	$\frac{2}{3}$ Uranus, m. p.,	12.2153
1.5 Saturn, m. a.,	15.0001	$\frac{1}{2}$ Neptune, mean,	15.0169
1.5 Uranus, m. a.,	30.0663	Neptune, mean,	30.0339
.6 Neptune, s. a.,	18.2817	Uranus, m. p.,	18.3230

The ratio of the rotating radius to the projectile radius of mean rotary *vis viva* is 2.5; the reciprocal ratio gives the vector-ratio in opposition, 1.5; the ratio of the rotating radius, less that of the projectile radius is .6; the reciprocal of 1.5 is $\frac{2}{3}$, which also represents the centre of linear oscillation and the radius of subsidence-collision; the viscous rupturing radius of subsidence is $\frac{1}{2}$.

371. *Reaction of Rotary Vis Viva.*

A fact which has an important bearing on Delaunay's hypothesis, as well as on the second law of thermodynamics, is shown by the reciprocal ratios of the foregoing note, and more strikingly, by the reactionary influence of Neptune. If we look to a like reaction on the part of the other planets, we find the following harmonic accordances:

.6 Uranus, m. a.,	12.0265	.4 Neptune, m.,	12.0135
.6 Uranus, s. p.,	10.6128	Saturn, s. a.,	10.3433
.6 Saturn, s. p.,	5.2407	Jupiter, m.,	5.2028
.6 Jupiter, m.,	3.1217	Asteroid 120,	3.121
.6 Jupiter, m. p.,	2.9869	Asteroid 61,	2.987
.6 Mars, s. a.,	1.0419	Earth, m. a.,	1.0338
.6 Earth, s. a.,	.6406	Venus, s. p.,	.6722
.6 Venus, m. a.,	.4493	Mercury, m. a.,	.4554
.6 Mercury, s. p.,	.1784	Laplace's limit,	.1696

The greatest deviations are at Earth's secular aphelion or locus of incipient subsidence, and at Mercury's secular perihelion or locus of incipient projection; the difference in each case being about five per cent. (1.0493 and .9507), and the mean difference being zero. The mean deviation of the four dense planets is only $\frac{1}{10}$ of one per cent. The mean difference in the light belt is about $\frac{2}{3}$ of one per cent., the greatest being that of Uranus, 2.5 per cent. The exactness of Jupiter's influence on Asteroids 120 and 61 is remarkable.

372. *Conservative Reaction.*

It may be readily seen that all the indications of the foregoing note point to a rotary *vis viva* of the several planets, reacting against a similar solar *vis viva*, and having no corresponding indications in opposition to the Sun. These indications are of a character like those which underlie the investigations of George H. Darwin, but their influence upon Sun is accelerating, instead of retarding, while any *quasi*-viscous tidal influence is retarding, instead of accelerating. If the two kinds of influence represent equal actions and reactions, the result would be a precise conservation of centripetal and radiant energies, without any solar expansion or contraction, other than in cyclic alternations, within limits of an order of magnitude like that of planetary eccentricities. The fundamental equality of Note 321 shows that Sun's centripetal rotating energy is wholly photodynamic. We may readily believe that the solar rupturing and expanding tendencies of planetary rotation represent a purely photodynamic reaction on gravitating action, which is exactly equivalent and opposite. The evidences of such equivalence in cosmical aggregations should encourage us to look, with increasing confidence, for further evidences in æthereal oscillations of various kinds, and especially in the electric and thermal undulations which are indicated by the fundamental equality. Edlund's researches point to electric and thermal equivalence of action and reaction, as plainly as Maxwell's point to electric and photic equivalence, and as my own point to a like photic, electric, thermal and gravitating equivalence.

373. *The Testimony of Mars.*

The many indications which I have found, of subsidence-orbital relations between Mars and the asteroidal belt, are supplemented by the direct and reciprocal influences (2.5 and 1.5; see Note 370), of solar photodynamic rotation upon the secular apsides and the mean locus of Mars, as well as upon intermediate positions.

2.5 sec. per.,	3.277	.6 Jupiter, m. a.,	3.256
1.5 sec. per.,	1.966	½ Asteroid 153,	1.977
2.5 mean,	3.809	.4 Saturn, m,	3.815
1.5 mean,	2.286	Asteroid 136,	2.287
2.5 sec. aph.,	4.341	.8 Jupiter, m. a.,	4.342
1.5 sec. aph.,	2.605	Asteroid 132,	2.603
.4 sec. aph.,	.695	Venus, m. p.,	.698
Mean	2.711	Mean	2.711

The greatest deviation is $\frac{3}{4}$ of one per cent. The two mean asteroidal accordances are nearly as exact as those in Note 371. All of the direct and reciprocal influences are in the asteroidal belt. The direct influence at secular aphelion (4.341) points to a "viscous" rupturing influence of the Jupiter-Saturnian belt (.4 of 10.855 = 4.342). The exact agreement of the general means is very satisfactory.

374. *Centripetal Influence of Rotary Vis Viva.*

Some of my critics have supposed that it would be possible to find harmonic accordances with series which were taken at random, or with no known kinetic basis, but none of them have offered any such accordances to confirm their supposition. I have never published any harmónies which were not the natural outgrowth of well-known elastic laws, and the abundant confirmation which I have found for my anticipations is beyond all cavil or gainsaying. In Note 370 I gave evidences of the centrifugal influence of rotary *vis viva*, which may be compared with the following evidences of mean centripetal influence.

.4 Neptune	12.014	$\frac{3}{4}$ Uranus, m. p.,	12.215
.4 Uranus,	7.673	$\frac{1}{2}$ (Jup. and Sat.), m. a.,	7.714
.4 Saturn,	3.816	2.5 Mars,	3.809
.4 Jupiter,	2.081	$\frac{3}{4}$ Asteroid 120,	2.081
.4 Asteroid 3,	1.067	Earth, s. a.,	1.068
.4 Asteroid 4,	.944	Earth s. p.,	.932
.4 Mars,	.609	Venus, s. p.,	.672
.4 Earth,	.400	Mercury, mean,	.387
.4 Venus,	.289	Mercury, s. p.,	.297

375. *Lines of Force and of Motion.*

Taylor (*op. cit.* p. 28), very properly calls attention to the fact that "no atom can perform an oscillation or a revolution, or follow any other path than a straight line, excepting under the coercion of other atoms attracting and repelling. The first law of motion is that of perfect continuity both in amount and in direction. A shuttlecock rebounding in the empty air would not be more conspicuously a dynamic solecism and impossibility than the kinematists 'vibratory particle.'" His doctrine (*Ib.* p. 9), that elasticity is "a fact of nature, a property of matter, which can neither be interpreted by any form of motion, nor resolved into any mechanical concept," is in precise accordance with the due regard to "lines of force" which guided Boscovich and Faraday, and which has been very helpful in my own researches. My first paper on barometric estimates of solar mass and distance (*Proc. Amer. Phil. Soc.*, ix, 283–8) was attacked by kinematists, because it violated some of their preconceived notions respecting the composition and resolution of forces. It did not receive much favor, until the productiveness of the harmonic methods showed that the composition and resolution of motions, in elastic media, may often enable us to dispense with intricate integrations, which it would be difficult, if not impossible to solve, and that it is always safer to be guided by the FACTS of nature, than by any preconceived theoretical interpretation of those facts.

Some Microscopic Distinctions between Good and Bad Timber of the Same Species. By Dr. J. T. Rothrock.

(*Read before the American Philosophical Society, February 2, 1883.*)

A cross section of one of our ordinary "hard woods" shows, more or less conspicuously, pores which are known as ducts, and which from their relatively large size are distinctly visible to the naked eye; secondly, it shows much smaller pores which may, or may not, require the magnifying glass to detect, and whose walls constitute the woody fibre of the stick; thirdly, we should have (assuming the specimen to be an exogen), the annual rings which mark, *as a rule*, the limit of each year's growth; fourthly, there would be the radial lines extending from the centre outwardly to the bark, these being the medullary rays or the so-called "silver grain."

If, on the other hand, the specimen under observation were one of our ordinary cone bearing trees, the ducts would be wanting, and the mass of the section would be composed of woody fibre. There may be openings which will resemble the ducts in hard wood, but instead of showing regularly organized walls, these will be found to represent simply openings left by the destruction or the separation of the woody fibres. They are by no means so numerous ordinarily as the ducts in an average "hard wood stick."

Considered from the standpoint of resistance to longitudinal strain, the strength-giving element of wood is the woody fibre; and other things being equal, it is strong in proportion as the fibre walls are relatively thick, and the fibre cavities relatively small. Illustrating this, we have the following cross sections of wood fibres, all magnified 242 diameters: 1, is that of Abies subalpina (Pumpkin Pine) from Utah; a timber which is almost worthless; 2, is that of our American Linden; 3, represents the Butternut (or Juglans cinerea); 4, is the Pig-nut Hickory (or Carya porcina) and 5, is that of an average specimen of White Oak fibre (Quercus alba). Considering the areas of the cavities in each of these sections, the White Oak has about six times as much wood in its walls, as there is in that of the Pumpkin Pine—a fact which it must be allowed will go far toward explaining the differences in the strength of the two woods. It is true that there may be differences in the strength of wood which are due to the molecular differences involved in the structure of the fibre, but with these we are probably in no position to deal. The intercellular substance which is destroyed by boiling in nitric acid and potassium chlorate is to a certain extent an element in the strength of wood. There can be no doubt but that it aids in increasing the friction between the individual fibres, and is therefore the chief agent by which these are bound together, and thus resist longitudinal strain. So far as my investigations go, there is less relation between length of fibre and strength, than there is between thickness of fibre wall and strength. Some woods acquire additional strength, both longitudinal and transverse, from a twisting of the wood fibres among themselves. The Rock Elm is a notable example of this among our larger trees; as the Viburnum nudum or Withe-rod is among the shrubs.

So far as the ducts are concerned, while the material of which they are composed may be quite as strong as that of the fibres, yet owing to the enormous cavity they contain, it is apparent that as compared with fibres, they must be much weaker; that in fact every duct is to be regarded as an element of weakness to the stick. Hence then, other things being equal, the more fibres and the fewer ducts, the stronger is any given stick of timber as compared with another of the same species.

The question of durability in exposed positions is quite another thing, and has no close relation to strength.

Accepting the above facts as proven, mere examination of a cross section of timber with the naked eye, or at most with an ordinary hand lens, may afford a reasonably safe way of estimating the quality of a given specimen of wood.

Associated with the appearance presented by the ducts, and the mass of fibres, is another element of structure, *i. e.*, that of the annual rings. These are usually caused as may be seen (A and B 6) by the thick, flat cells which are formed in autumn as contrasted (A and B 7) with the larger ones which mark the first growth of the ensuing spring. The number of rows which are thus flattened in the autumn wood is by no means constant. Sometimes, as in the case of the White Oak, there being but two, three or four; or as in the case of the Chestnut being often about eight, or more; or as in the Redwood of California (Sequoia sempervirens) as high as fifteen. As a rule the color in all these autumn fibres is deeper than in those made earlier. Hence both shape and color combine to mark the "year's growth."

The term "year's growth" is one which should not be depended upon too absolutely, inasmuch as it is well known to be misleading at times. Thus, in the American Linden, one frequently sees a ring more on one side than on the other; and indications are not wanting, which would prove that very frequently several such rings may form in our latitude in a single season.

There are some facts of practical importance connected with the wood formed during the season, or to speak more accurately, with all the tissue lying between the denser, flatter fibres which are assumed to be formed in the autumns of two successive years. In White Oak, as shown by figures A and B, there may be a great range in the distance between these zones of flat fibres. Thus fig. B shows that the growth for the year was about twice that shown by fig. A. The former of these figures represents a good specimen of White Oak, and the latter a bad one, each having been carefully tested for strength by competent mechanical experimenters. In these instances the reason for the difference in the quality of the wood is obviously in the relative predominance of solid woody fibre over open ducts in the good specimen (B), and the lesser quantity of wood as compared with ducts in (A), the bad. It so happens that in A the diameter of the duct (.01430 of an inch) is greater by far than in the better wood. This can, however, hardly be regarded as constant. What does appear to prevail in White Oak is, the fact that most of these *large* ducts are made early in the

season, and that whether much or little wood is subsequently formed the number of the ducts will not greatly vary. Hence, then, for White Oak we may assert that the specimen with the larger year's growth is, other things being equal, the better. Very frequently two duct cavities are thrown into one, so that the width is greatly increased. These may usually be distinguished from true ducts by the irregular and disintegrated walls, which serve to explain the process by which the size was attained.* The above rule, as to the relation between size of "year's growth" and value, in Oak I have made the subject of some investigation, taking as test cases specimens of timber upon whose value opinions had been given by the most competent workers in the wood.

Hickory, good and bad (certainly Carya alba and C. porcina), involves another element than mere size of the annual ring. Though I must here add that the best bit of C. porcina I have ever seen was also one that had the largest year's growth I had ever seen. In this wood (Hickory), the large ducts are not so clearly limited in their production to the early part of the season (especially if the stick be one of poor quality), but are, or may be, clearly scattered through the wood. And the quality of the wood is determined mainly by the number and size of these ducts. Thus in bad Pig-Nut Hickory (C. porcina) I find in a surface of a quarter of an inch square, sixty-five, each with an average size of .01428 inch; as against twenty-seven ducts having an average width of .01224 inch in good Hickory of the same species.

To a greater or less extent the same statements, as to cause of difference between good and bad qualities of Chestnut, and Locust (Robinia pseud-acacia), will apply.

Figure C. illustrates the marked tendency which the ducts have to be associated in Hickory. It also shows the effect of the growth in pushing aside one of the medullary rays, 9 b. It is not uncommon, however, in this wood to find these rays broken by the growth of the duct, and in Oak this is still less rare. I have frequently seen specimens of bad White Oak which were as porous as the average Red Oak, the ducts being, as shown by the micrometer, quite as great in their diameter.

The medullary rays or "silver grain" appear also to have important relation to value of Oak certainly, and probably of Hickory, to say nothing of other kinds of timber. The fibres and ducts are ordinarily characterized as the vertical system from the line in which they are elongated. With equal propriety then the medullary rays are spoken of as the horizontal system of the plant, because they are elongated at right angles to the fibres and ducts. From the thick walls of the cells constituting these rays, we might suppose they had to do with the lateral strength of the timber. This view is *partially* confirmed by a microscopic examination of the cross section of the different woods; as upon the whole, Red-wood, Chestnut and White Pine show either that these rays are fewer in number or less strongly

* Very often this process of disintegration of the wall may convert a true duct into a mere cavity without walls.

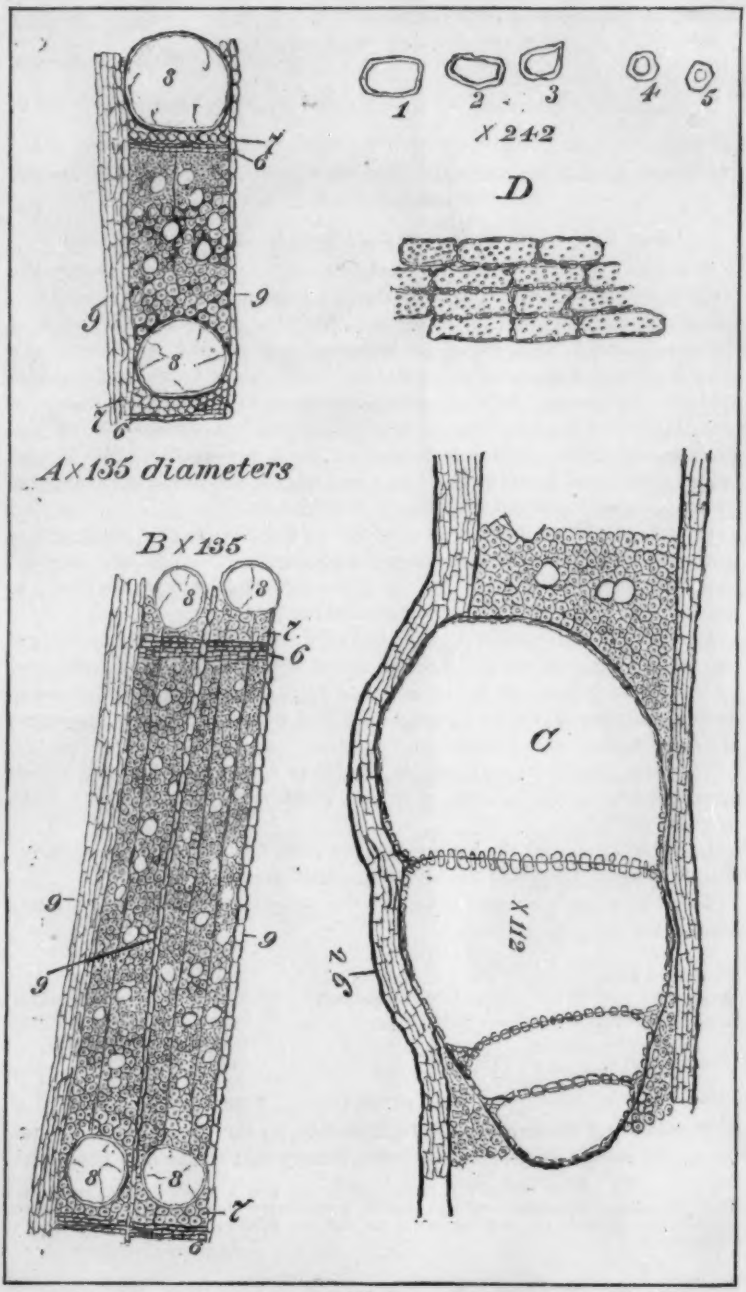
developed than in the Tupelo (Nyssa multiflora), or in a specimen of good White Oak. However, in making comparisons of this kind, we must be careful to make them at points equidistant from the centre; and to note whether these rays extend to the centre, or only part way in from the bark toward the heart of the tree, as this latter circumstance determines their age, and also generally their relative strength. In such species of timber as have rays extending vertically over two or more inches, as in some of the Oaks, the ray often indicates the line of easiest splitting, as is often seen by the effect of drying upon the exposed end of such timber. This is not an invalidation of the statement that one function of the rays appears to be to give lateral tenacity, *i. e.* to such portions of solid wood as lie between the rays. They form as it were a chain binding the periphery to the centre, but offer no resistance to the separation of one woody wedge which they outline, from another such wedge which is placed alongside. If this be so, then such specimens of wood as have the rays ruptured by encroachment of ducts or by any process of disintegration would be correspondingly weakened. It is furthermore worthy of note that in such specimens of good White Oak (Quercus alba), and good Pig-Nut Hickory (C. porcina) as upon actual trial had proven to be the best, these rays were as a rule either most numerous, or best developed, or both.

Examined microscopically, the cells making up these rays present an appearance when viewed from the side like figure D. That is to say they are quadrangular, thick walled and with numerous thin places in which the primary cell wall may or may not remain. Their very appearance suggests a somewhat easy communication between those (cells) which are adjacent, and thus afford a probable explanation of the fact, that when the starch made in summer by the younger portion of the tree is being conveyed into the interior of the branches for winter storage, these rays appear to furnish the most available avenues for accomplishing the work, and micro-chemical tests show that it is most abundant in them. While these thin or open places in the cells of the medullar ray usually communicate with each other, it is remarkable that they are much fewer in the sides toward the ducts and fibres.

It would be exceedingly interesting to know how far the facts indicated by this paper would conform to the value of timber as determined by specific gravity.

EXPLANATION OF ILLUSTRATIONS.

1. Cross Section of Abies subalpina wood fibre × 242.
2. " " Tilia Americana " " × 242.
3. " " Juglans cinerea, " " × 242.
4. " " Carya porcina, " " × 242.
5. " " Quercus alba " " × 242.
6. A and B. Flattened cells made in autumn.
7. " " Larger cells which indicate growth of following spring.
8. " " Open ducts seen in cross section.
9. " " Medullary rays.


8
7
6
9
9
8
7
6
A×135 diameters
1
2
3
4
5
×242
D
B×135
8
8
7
6
9
9
9
8
8
7
6
C
×112
2
6

A. Cross section of bad White Oak × 135.
B. " " good " " × 135.
C. " " Carya porcina × 112, grouping of ducts and pushing aside of Medullary rays.
D. Fragment of Medullary ray showing the pits or pores in the walls, × 300.

An improvement in the construction of the Hypsometrical Aneroid. By Dr. Persifor Frazer.

(*Read before the American Philosophical Society, March 2, 1883.*)

While in France last year the idea occurred to the writer to lessen the weight of the delicate Hicks Barometer by constructing as much as possible of it of aluminium. Supposing that this could be done without difficulty, though of course at an increased expense, the writer devised a case of cork to contain it, and wrote to Mr. Hicks of London asking him to make the attempt. After a number of interviews it was finally estimated that the cost of the new form of aneroid should not exceed £10, or just double that of the ordinary instrument of brass in a wooden case. Delays were experienced from the beginning and added very much to the expense of the instruments when they finally arrived here.

First it was found difficult to produce an aluminium dial plate with a graduation of the requisite delicacy and accuracy. Then the internal supports could not be easily cast in that metal of the shapes necessary to build the frame for the more delicate moving parts.

Finally the writer was obliged to leave England without having received the barometers. When they arrived a few days ago the Government duty on them was $30.40 a piece, added to which Mr. Hicks had found it necessary to increase the original charge of £10 to £15 apiece. In consequence they cost a little over $105 apiece.

They are, however, creditable to Mr. Hicks's workmanship, and if their manufacture should increase, could no doubt be obtained at a very much reduced price.*

In order to prevent the breaking of the cork, by friction on the clothing, a light canvas cover was added, weighing 50 grams.

The following is a comparison of the weights of the ordinary Hicks barometer with one of them.

	Old form.		New form.	
Case and strap,	400 grams.	(wood)	150 grams.	(cork)
Aneroid,	1000 "	(brass)	400 "	(Aluminium)
Canvas cover,	——		50 "	
Total weight,	1400 "		600 "	
" "	or 3.09 lbs.	(av.)	1.323 lbs.	(av.)

The ordinary instrument weighs, therefore, 2¼ times as much as the new form, the weight of the old case being closely that of the new barometer.

* A letter received from Mr. Hicks, after the above was in print, reiterates the difficulties with which he contended, and states that notwithstanding the experience gained in making mine, he cannot deliver them for less than £15 apiece.

Some Comparative Tables showing the Distribution of Ferns in the United States of North America. By George E. Davenport.

(*Read before the American Philosophical Society, February 2, 1883.*)

The following tables have been prepared for a Text Book and Manual of the Ferns of North America (north of Mexico), but are believed to be of sufficient interest to justify publication in advance.

The attention of botanists is called to them, and their coöperation solicited in enabling the writer to render them more complete and accurate for final publication.

These tables are necessarily incomplete in their present form, no reliable data for all of the States and Territories being readily accessible. The number of species credited to many of the States might have been increased by assuming the presence of certain species from their well known geographical range, but it was thought best to give only those which could be verified, or had been vouched for by good authority.

Where a doubt exists in regard to the presence of a species said to have been collected in any State, and such doubt is not sufficient to justify exclusion, the species is credited with a query to indicate the uncertainty of its verification.

All varieties are excluded except where a variety stands as the sole representative of the species itself.

My thanks are due to John H. Redfield, Dr. George Engelmann, Professor D. C. Eaton, J. Donnell Smith and Wm. Stout for many additions, and it will further aid me greatly if others will send to me accurate lists of the species and varieties known to grow naturally in their respective States.

The list of ferns as given below may undergo some changes before final publication, the numbers correspond to those given in the tables:

1. Acrostichum aureum.
2. Polypodium Plumula.
3. " pectinatum.
4. " vulgare.
5. " falcatum.
6. " Californicum.
7. " incanum.
8. " Scouleri.
9. " Phyllitidis.
10. " aureum.
11. Gym. triangularis.
12. " hispida.
13. Notholæna sinuata.
14. " ferruginea.
15. " candida.
16. " Hookeri.
17. " Grayi.
18. Notholæna Lemmoni.
19. " Fendleri.
20. " dealbata.
21. " nivea.
22. " Newberryi.
23. " Parryi.
24. " tenera.
25. Cheilanthes Californica.
26. " Wrightii.
27. " viscida.
28. " microphylla.
29. " Alabamensis.
30. " leucopoda.
31. " vestita.
32. " Cooperæ.
33. " lanuginosa.
34. " gracillima.

35. Cheilanthes tomentosa.
36. " Eatoni.
37. " Fendleri.
38. " Clevelandii.
39. " Parishii.
40. " Lindheimeri.
41. " myriophylla.
42. " argentea.
43. Cryptogramme acrostichoides.
44. Pellæa gracilis.
45. " Breweri.
46. " Bridgesii.
47. " atropurpurea.
48. " aspera.
49. " Wrightiana.
50. " ternifolia.
51. " ornithopus.
52. " brachyptera.
53. " andromedæfolia.
54. " cordata. ?
55. " flexuosa.
56. " pulchella.
57. " densa.
58. Pteris longifolia.
59. " Cretica.
60. " serrulata.
61. " aquilina.
62. Ceratopteris thalictroides.
63. Adiantum pedatum.
64. " emarginatum.
65. " tricholepis.
66. " capillus-veneris.
67. " tenerum.
68. Vittaria lineata.
69. Tænitis lanceolata.
70. Blechnum serrulatum.
71. Lomaria spicant.
72. Woodwardia radicans.
73. " Virginica.
74. " angustifolia.
75. Camptosorus rhizophyllus.
76. Scolopendrium vulgare.
77. Asplenium serratum.
78. " pinnatifidum.
79. " ebenoides.
80. " ebeneum.
81. Asplenium parvulum.
82. " Trichomanes.
83. " viride.
84. " dentatum.
85. " montanum.
86. " Bradleyi.
87. " Ruta-muraria.
88. " septentrionale.
89. " firmum.
90. " myriophyllum.
91. " cicutarium.
92. " angustifolium.
93. " thelypteroides.
94. " Filix-fœmina.
95. Phegopteris polypodioides.
96. " hexagonoptera.
97. " Dryopteris.*
98. " alpestris.
99. Aspidium Lonchitis.
100. " acrostichoides.
101. " munitum.
102. " aculeatum.
103. " Mohrioides.
104. " Thelypteris.
105. " Noveboracense.
106. " Nevadense.
107. " Oreopteris.
108. " conterminum.
109. " patens.
110. " fragrans.
111. " spinulosum.
112. " Boottii.
113. " cristatum.
114. " Floridanum.
115. " Goldieanum.
116. " rigidum.
117. " Filix-mas.
118. " marginale.
119. " unitum.
120. " juglandifolium.
121. " trifoliatum.
122. Onoclea sensibilis.
123. " Struthiopteris.
124. Cystopteris fragilis.
125. " bulbifera.
126. " montana.

* *Phegopteris calcarea* is included here as a variety with Hooker and Baker.

127. Woodsia Ilvensis.
128. " glabella.
129. " hyperborea.
130. " scopulina.
131. " Oregana.
132. " Mexicana.
133. " obtusa.*
134. Nephrolepis exaltata.
135. Dicksonia pilosiuscula.
136. Trichomanes Petersii.
137. " radicans.
138. Schizæa pusilla.
139. Aneimia Mexicana.
140. " adiantifolia.
141. Lygodium palmatum.
142. Osmunda regalis.
143. " Claytoniana.
144. " cinnamomea.
145. Botrychium simplex.
146. " Lunaria.
147. " boreale.
148. " matricariæfolium.
149. " lanceolatum.
150. " ternatum.
151. " Virginianum.
152. Ophioglossum vulgatum.
153. " crotalophoroides.
154. " nudicaule.
155. " palmatum.

Tables Showing Distribution.

Numbers correspond with those to the List.
*Verified or credited on good authority.
?Uncertain, or not positively verified.

	TOTAL.
Alabama—4, 7, 29, 31?, 47, 60, 61, 63, 66, 75, 78, 79, 80, 81, 82, 83, 86, 92, 93, 100, 105, 118, 133, 135, 136, 137, 142?, 150, 152, 153, 154.	29* 2?
Alaska—4, 42?, 43, 63, 71, 95, 97, 98, 102, 107, 111, 124, 126, 145, 146, 147, 148, 149, 150, 152.	19* 1?
Arizona—4, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 29, 33? 35, 36, 37, 40, 41, 43?, 47, 49, 53?, 54, 55, 61, 63, 66, 104, 109, 117, 124, 130, 131, 132, 133, 151, 152.	37* 3?
Arkansas—4, 7, 20, 29, 31, 33, 35, 47, 61, 63, 66, 73, 74, 75, 78, 80, 81, 82, 86, 87, 92, 94, 95, 96, 100, 104, 105, 111, 113, 118, 122, 123, 124, 125, 133, 142, 143, 1[illegible]4, 150, 151, 152.	41*
California—4, 5, 6, 8, 11, 15, 22, 23, 25, 27, 32, 33?, 34, 37, 38, 39, 41?, 43, 45, 46, 49, 51, 52, 53, 57, 61, 63, 64, 65?, 66, 71, 72, 82, 94, 95?, 98, 101, 102, 103, 106, 109, 116, 124, 130, 131, 145, 150, 151.	44* 4 ?
Colorado—4, 19, 33, 36, 37, 43, 44, 45, 47, 49, 61, 80, 82, 88, 94, 97, 99, 117, 124, 126, 130, 131, 145?, 146, 149, 151.	25* 1?
Connecticut—4, 47, 61, 63, 73, 74, 75, 79, 80, 82, 87, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 146, 148, 149, 150, 151, 152.	40*
Dakota—4, 33, 47, 61, 97, 99?, 111, 117, 122, 124, 125, 127, 130, 131, 150, 151.	15* 1?

* *Woodsia Plummeræ* Lemmon (Botanical Gazette Jan. 1882), is apparently a very glandular form of this species.

DELAWARE—4, 61, 63, 73, 74, 75, 80, 82, 93, 94, 96, 100, 104, 105, 112, 113, 115, 118, 122, 127, 133, 135, 142, 143, 144, 150, 151, 152. 28*

DIST. OF COLUMBIA—4, 47, 61, 63, 74, 80, 82, 92, 93, 94, 96, 100, 104, 105, 111, 118, 122, 125, 133, 141, 142, 143, 144, 150, 151, 152. 26*

FLORIDA—1, 2, 3, 7, 9, 10, 28, 58, 59, 61, 62, 66, 67, 68, 69, 70, 73, 74, 77, 80, 81?, 82, 84, 89, 90, 91, 94, 96, 100, 104, 108, 109, 114, 119, 121, 122, 134, 136?, 140, 141, 142, 143, 144, 150, 151, 153, 154, 155. 46* 2?

GEORGIA—29, 31, 61, 73, 74, 75, 81, 85, 93, 122, 133, 142, 144, 154. 14*

IDAHO—61, 94, 102. 3*

ILLINOIS—4, 7, 33, 47, 61, 63, 73?, 75, 78, 80, 82, 93, 94, 95, 96, 97, 100, 104, 105, 111?, 118, 122, 123, 124, 125, 133, 135, 142, 143, 144, 150, 151. 30* 2?

INDIANA—4, 7, 31, 47, 61, 63, 73, 75, 78, 80, 82, 87, 92, 93, 94, 96, 100 104, 105, 111?, 115, 117?, 118, 122, 123, 124, 125, 133, 135, 142, 143, 144, 150, 151, 152. 33* 2?

INDIAN TERRITORY—36, 47, 115, 133. 4*

IOWA—4, 33, 44, 61, 63, 80, 82, 94, 95. 9*

KANSAS—20, 31?, 47, 63, 75, 92, 115, 122, 124, 133, 151. 10* 1?

KENTUCKY—4, 7, 31, 35, 47, 61, 63, 66, 75, 78, 79, 80, 81, 82, 85, 86, 87, 92, 93, 94, 95, 96, 100, 104, 105, 111, 113, 115, 118, 122, 124, 125, 127?, 133, 135, 137, 141, 142, 143, 144, 150, 151, 152?. 41* 2?

LOUISIANA—7, 61, 63, 73, 74, 80, 92, 93, 94, 95, 100, 104, 105, 109, 111, 114, 122, 125, 142, 144, 150, 151, 153. 23

MAINE—4, 61, 63, 73, 80, 82, 94, 95, 96, 97, 100, 102?, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 142, 143, 144, 145, 148, 149, 150, 151, 152. 35* 1?

MARYLAND—4, 31, 61, 63, 73, 74, 75, 78, 80, 82, 85, 87, 93, 94, 95, 96, 100, 104, 105, 111, 112, 113, 115, 118, 122, 124, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152. 36*

MASSACHUSETTS—4, 44, 47, 61, 63, 73, 74, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 145, 148, 149, 150, 151, 152. 42*

MICHIGAN—4, 43, 44, 47, 61, 63, 73, 74, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 99, 100, 102, 104, 105, 110, 111, 112, 113, 115, 117, 118, 122, 123, 124, 125, 127, 131, 133, 135, 142, 143, 144, 145, 146, 148, 149, 150, 151. 47*

MINNESOTA—4, 31, 44, 47, 61, 63, 75, 93, 94, 95, 97, 100, 104, 110, 111, 115, 118, 123, 125, 127, 130, 143, 150, 151. 24*

MISSISSIPPI—7, 66, 73, 80, 94, 96, 100, 122, 142, 144, 150. 11*

MISSOURI—4, 7, 20, 31, 33, 35, 47, 61, 63, 66, 75, 78, 80, 82, 92, 93, 94, 96, 100, 104, 111, 118, 122, 124, 125, 133, 135, 142, 143, 144, 150, 151, 152. 33*

MONTANA—4, 97, 99, 111, 122, 124, 125, 127, 150, 151. 10*

NEBRASKA—4, 33, 44, 47, 61, 63, 75, 80, 82, 92, 94, 95, 96, 99, 104, 105, 110, 111, 113, 118, 124, 125, 127, 133, 135, 142, 143, 144, 150, 151. 30*

NEVADA—37, 103. 2*

NEW HAMPSHIRE—4, 44?, 47?, 61, 63, 73?, 75?, 80, 82, 87?, 93, 94, 95, 97, 100, 102, 104, 105?, 110, 111, 112?, 113, 115, 118, 122, 123, 124, 125?, 127, 128, 133, 135, 142, 143, 144, 148, 150, 151, 152. 31* 8?

NEW JERSEY—4, 31, 44, 61, 63, 73, 74, 75, 79?, 80, 82, 83, 85, 87, 93, 94, 96, 100, 104, 105, 111, 113, 115, 118, 122, 124, 125, 127, 133, 135, 138, 141, 142, 143, 144, 149, 150, 151, 152. 38* 1?

NEW MEXICO—12, 13, 14, 16, 19, 20, 21?, 26, 28?, 29, 33, 34, 36, 37, 40, 47, 48?, 49, 50?, 54, 55?, 56, 66, 81, 82, 88, 124, 131? 132, 133, 139. 25* 6?

NEW YORK—4, 31, 44, 47, 61, 63, 73, 74, 75, 76, 79, 80, 82, 85, 86, 87, 92, 93, 94, 95, 96, 97, 100, 102, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 128, 129, 133, 135, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 152. 52*

NORTH CAROLINA—4, 7, 29, 31, 35, 47, 61, 63, 66, 74, 75, 78, 80, 81, 82, 85, 87, 92, 93, 94, 96, 100, 104, 105, 111, 118, 122, 124, 125, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152. 39*

OHIO—4, 7, 47, 61, 63, 73, 75, 80, 82, 87, 92, 93, 94, 95, 96, 97, 100, 104, 105, 111, 113, 115, 118, 122, 123, 124, 125, 127?, 133?, 135, 142, 143, 144, 150, 151, 152. 34* 2?

OREGON—4, 5, 6, 8, 11, 34, 43, 46, 57, 61, 63, 64, 71, 82, 94, 97, 98, 101, 111, 124, 130, 131, 133, 151. 24*

PENNSYLVANIA—4, 31, 44, 47, 61, 63, 73, 74?, 75, 78, 79, 80, 82, 85, 87, 92, 93, 94, 96, 97, 100, 102, 104, 105, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 148?, 150, 151, 152. 42* 2?

RHODE ISLAND—4, 61, 63, 73, 74, 75, 80, 82, 93, 94, 95, 96, 97, 100, 104, 105, 111, 112, 113, 118, 122, 123, 124, 125, 127, 133, 135, 141, 142, 143, 144, 150, 151, 152. 34*

SOUTH CAROLINA—7, 73, 80, 82, 84?, 109, 150, 153, 154. 8* 1?

TENNESSEE—7, 29, 35, 61, 63, 75, 76, 78, 81, 82, 85, 86, 87, 100, 111, 124, 125, 133, 135, 137, 141, 152. 22*

TEXAS—7, 12, 13, 14, 15, 16, 20, 26, 28, 29, 30, 33, 35, 40, 47, 48, 49, 50, 54, 55, 56, 61, 65, 66, 80, 81, 82, 109, 120, 121, 132, 133, 139, 152, 153. 35*

UTAH—23, 24, 33, 43, 45, 57, 61, 63, 66, 94, 99, 103, 117, 130, 131. 15*

VERMONT—4, 44, 47, 61, 63, 73, 75, 80, 82, 83, 87, 92, 93, 94, 95, 96, 97, 100, 102, 104, 105, 110, 111, 112, 113, 115, 118, 122, 123, 124, 125, 127, 128, 129, 133, 135, 142, 143, 144, 145, 148, 149, 150, 151, 152. 45*

VIRGINIA, including W. Va.—4, 7, 31, 35, 61, 63, 66, 74, 75?, 80, 81, 82, 85, 87, 92, 93, 94, 97, 104, 105, 111, 113, 115, 118, 124, 127, 133, 135, 141, 142?, 144?, 150, 151. 30* 3?

WASHINGTON TERRITORY—4, 5, 8, 11, 34, 43, 57, 61, 63, 71, 82, 94, 99, 101, 103, 111, 124, 130, 145, 150, 151, 152. 21* 1?

WISCONSIN—4, 31, 33, 44 ·47, 61, 63, 75, 80, 82, 92, 93, 94, 95, 97, 100, 104, 105, 110, 111, 113, 115, 118, 122, 123, 124, 125, 127, 133, 135, 142, 143, 144, 150, 151. 35*

WYOMING TERRITORY—57, 131, 145, 150. 4*

REMARKS. No positively accurate comparisons can be made from the incomplete data furnished by these partial tables, but so far as now known. New York, Michigan, Florida, Vermont and California, in the order named, have the greatest number of species of ferns within their respective limits.

In the first, second and fourth of these States, the number has, in all probability, reached, or very nearly reached, its maximum, while in the third and fifth it is likely to be largely increased, and those States from their favorable situations, climates, and comparatively extensive, unexplored territory, will, undoubtedly, lead all other States in the future. Arizona and Texas alone being at all likely to compete with them for the highest place.

If, however, we distribute our ferns according to the number of square miles of territory which each of the five first named States contains, then Vermont will lead the others, her ratio being as 1 fern to every 226⅔ square miles, that for New York as 1 to 814, Michigan 1 to 1191½, Florida, 1 to 1289, and California 1 to 4295½ square miles of territory.

Taking the extremes of the territorial limits, excluding the District of Columbia, which has 1 species to each 2½ miles of territory, Rhode Island gives us 1 species for each 38¼, and Delaware 1 to 75, as compared with Pennsylvania's 1 to 109¼, Colorado's 1 to 4200 and Texas 1 to 7878⅔ square miles.

If we take an average of the fern flora for the different geographical sections of the United States, on the basis of the present list, New England gives us an average of 40 species for each State, the Middle Atlantic States 40, the South Atlantic 27, the Gulf States 23, and the Central States 25, the Pacific States 23, and the Territories an average of 19.

The returns from most of the Territories are altogether too meagre at present to permit of any comparisons, and those already made will necessarily undergo considerable modification as the gaps in the lists for other States fill up.

But while no absolutely reliable comparisons can be made, nor the pre-

cise limits of each species be determined from the present incomplete tables, we may ascertain from them, with a tolerable degree of certainty, the range of certain species, and find material for some interesting observations.

Thus we find the cosmopolitan *Asplenium trichomanes* and *Pteris aquilina* in thirty-five and thirty-nine, out of the forty-eight States and Territories respectively, while their actual presence in a greater number may be safely assumed. *Polypodium vulgare* appears in thirty-three, with the same, or an even greater probability of its occurring in others in its favor, while its near congeners, *P. californicum*, and *P. falcatum*, as well as *P. scouleri* are restricted to two or three States. Of the remaining Polypodiums, all but *incanum*, which appears in twelve States are restricted to the single State of Florida, which furthermore monopolizes all the species we have in six genera, the tropical character of these being at once indicated by this fact.

The only other State (since the discovery of Scolopendrium in Tennessee has divided with New York the honor of that ferns presence) which may now claim a monopoly of a genus is New Jersey, the very local *Schizæa* being restricted to a portion of its limits and again restricted to a single species.

Adiantum pedatum occurs in thirty-five States or Territories, while its congener, *A. capillus-veneris*, is restricted to thirteen, and the tropical *A. tenerum* to a single State.

The Osmundas are represented by one or more species in twenty-nine, Onoclea in twenty eight States or Territories, and these probably occur in more, although not reported west of the Rocky mountains. *O. sensibilis* extends as far west as Dakota and Montana, and in the last mentioned Territory is said to have been discovered in a fossil state.

Cystopteris fragilis extends from Maine to California, through thirty-three States and Territories, apparently avoiding the South Atlantic and Gulf States, with the exception of North Carolina, while *C. bulbifera* occurs in twenty-five, covering a more unequal, but broader range south and west, the limits of which terminate in Louisiana and Dakota. *C. montana* so recently discovered in Colorado by Brandegee is reported elsewhere in the United States only from Alaska. The Aspidia are represented in forty-four, the Asplenia and Botrychia in forty-one States or Territories each, while the drought-resisting Gymnogrammes, Notholænas, Cheilanthes, and Pellæas are almost wholly restricted to the arid regions west of the Rocky mountains, a few scattering species only coming East, North or South.

It is interesting to note the changes which have taken place in the number and distribution of our ferns since Redfield published his valuable paper on the "Geographical Distribution of the Ferns of North America," in the Torrey Club Bulletin for January, 1875, and Watt, his admirable review of Mrs. Lyell's Hand-Book in the Canadian *Naturalist* for 1870. Mr. Redfield enumerated 125 species, which have been increased up to the pres-

ent time to 153 or 156, according as we may consider the claims of certain ferns to specific rank, or their right to a place in our fern-flora, while the range of the older species has been more or less extended.

Taking the number in the list accompanying this paper for a basis, viz., 155, we have an increase of 30 species since 1875, and we may confidently expect a still greater increase as the vast regions of Arizona, New Mexico and Western Texas are more thoroughly explored.

Fournier enumerates 505 Mexican species, of which number only 55 are known to occur within our own limits; but how many of the remaining 450 are lurking in the cañons this side of the Mexican border, to reward the patient search of keen-eyed botanists, remains yet to be made known.

SUPPLEMENTARY.

The foregoing tables were prepared in March, 1882. Since that time several additions have been made to our Fern Flora, and many additional credits noted; these have so changed the status of the leading States as given in the text, and are so interesting for comparisons by which to mark progressive changes in the future, that it seems best to place them on record here in a separate note.

By the certain addition of 7, and the probable addition of 1 or 2 more to the entire fern flora of the United States, our list is increased from 155 to 162 or 164.

Numbers 94, 99 and 151 are to be credited to Alaska; 45, 131 and 124 to Idaho; 117 to Washington Territory; 124 to Utah, and 97 (*Var. calcareum*) to Iowa.

California by the addition of numbers 24, 99, 117 and 154, advances from the fifth to the second place, and, if a little Woodsia lately received from Lower California proves to be *obtusa*, as seems probable, and the doubtful credits were verified, would lead New York.

Florida by the addition of *Polypodium Swartzii* takes rank for the present with Michigan, although if we concede the presence of the doubtful credits Michigan will still lead by one species and take rank as third, a position, however, which she would be almost certain to yield up, perhaps before the close of another season.

Arizona by the addition of 81, 120, *Polypodium thyssanolepis*, *Pellæa marginata*, *Cheilanthes lendigera*, *Cheilanthes* ——— sp.? *Notholæna Aschenhorniana*, *Asplenium monanthemum*, *Asplenium Glennici* and *Aspidium* ——— sp.? pushes rapidly to the front, contests the honor of third position with Florida and Michigan, and threatens before long to become a close competitor for the leading place.

Glancing over the entire field of our Fern Flora at the present time, it is safe to assume from the nature of her territory, and the close proximity of an extensive and almost unexplored mountainous area to a portion of Mexican territory rich in ferns, that Arizona in time will lead all the other States in the wealth of her fern flora.

Obituary Notice of the Rev. Dr. Charles Porterfield Krauth. By F. A. Muhlenberg.

(*Read before the American Philosophical Society, March 16, 1883.*)

Both sacred and profane history is largely made up of biography. It is true, great events are also therein described, as intimately connected with the life of man; but human beings themselves have ever been a more interesting study, than the changes produced by their agency. Man is the most luminous point, in the prose, or poetic narratives, found in the literature of all nations. His successes, his triumphs over obstacles, material and spiritual, as well his reverses, have been handed down, to successive generations, to imitate or avoid. Nations, civilized or uncivilized, have exalted through their bards, historians and orators, the fame of those, most eminent among them, in the varied departments of human enterprise or ambition, and have deposited these accounts in their archives, that the memory of their noble deeds might thus be perpetuated. The intuitions of the race have thus prompted them to pay a proper tribute to the divine and eternal in men. Thus the example of those most distinguished for their virtue, their learning, their benevolence, their skill, has always been a beacon light, to "allure to brighter worlds, and lead the way."

Such principles have, no doubt, influenced this venerable and honorable Society, to adopt the rule of having an Obituary Notice on the decease of one of its members. In accordance, therefore, with the wishes of this Society, and by the request and appointment of its honored President, we have prepared the following sketch of our lately deceased, much beloved, and illustrious member, Charles Porterfield Krauth.

The subject of our sketch was born in the town of Martinsburg, Va., March the 17th, 1823. His father was the Rev. Charles Philip Krauth, at that time pastor of the Lutheran Churches of Martinsburg and Shepherdstown, Va., and his mother's maiden name was Catherine Susan Heiskell, of Staunton, of the same State. Charles Philip Krauth was a native of Pennsylvania, having been born in Montgomery county, and was carefully educated in private in Greek, Latin and French by his father, who had emigrated to our State from Germany, in the capacity of teacher and organist, being a member of the German Reformed Church, whilst his wife was a Lutheran, and a native of this country. After the completion of his preparatory studies, under his father, having a preference for medicine, he pursued, for a time, his medical studies, as a pupil of Dr. Selden, of Norfolk, Va., and attended one course of lectures in the University of Maryland. From a conscientious change of views as to his duty, he abandoned medicine for the ministry, became, first, pastor of the churches in Virginia already mentioned; then in 1827, of St. Matthew's Lutheran Church in this city, whence he was transferred, in the year 1833, to Gettysburg, Pa., to become "Professor of Biblical and Oriental Literature," in the Theological Seminary of the Lutheran Church, there located,

and subsequently was elected President of Pennsylvania College, at the same place, in which useful and important positions, he labored with great fidelity and success, until his death in the year 1867, in the 71st year of his age.

The life, employments, and character of the elder Dr. Krauth, had so much to do with the usefulness and exalted fame of his son, Charles Porterfield Krauth, that the writer felt it to be necessary to give the above particulars with reference to him, and to append a few statements from some of those who knew him best, in regard to his extraordinary ability and excellence. In this way, we can obtain clear views of the genial and ennobling influences under which the younger Dr. Krauth was reared.

One of his most intimate friends, long associated with the father whilst he was President of Pennsylvania College, in an interesting sketch of his life, says of him: "A character so near perfection, a life so almost blameless is seldom found. He was one of the purest and best men that ever lived." Another friend, now Professor in Columbia College, gives us this estimate of him: "For me his character possessed attractions perfectly irresistible, and I loved him with an intensity that beggars description." A third gentleman, who spent a week with him at a comparatively early period of his life, remarks: "His conversation was so instructive, his counsels were so wise, his manners were so gentle, his spirits so buoyant that I learned more practical wisdom than in any other week of my life." It was the good fortune of the writer to know, and be intimately associated with this eminent man, for seventeen years; and it gives him pleasure to testify to the accuracy of his scholarship, soundness of judgment, keen perception, warmth of heart, eloquence of speech, nobility of nature, and eminence of Christian character. "He had," to use the terse language of a writer in Johnson's Encyclopædia, if I mistake not, his own son, recently deceased, "every quality which ensures a large distinction, except ambition."

Born of such parents, surrounded continually, from his earliest years, by such favorable influences for the improvement of his intellectual and moral powers, we have no difficulty in recognizing the cause, and in predicting, from such antecedents, the certainty of the future eminence of our lamented fellow-member. He had the same eminent endowments of his revered father, in an intensified form; the same keenness of perception, eloquence of speech, soundness of judgment, richness of imagination, and warmth of heart. Through his mother, he was, perhaps, also gifted with a vivacity greater than that enjoyed by his father. He thus united in himself the sober self-control of the Pennsylvanian, with the sprightliness and exuberant emotion of the Virginian. These native endowments were expanded also by early and constant companionship with his father, "who knew all literature," and his profoundly learned friends, "who knew all philosophy," and access to, and use of the valuable library he possessed. In society, as well as in the case of individuals, auspicious influences for growth, become cumulative, and a maximum good result is the product of

their combination. Children often thus exceed in eminence illustrious parents, by the possession of accumulated endowments, and the faithful use of increased opportunities of culture.

The son continued under the more immediate care of his father during the remainder of his ministry at Martinsburg, his pastorate in Philadelphia, and the earlier years of his residence in Gettysburg. After the removal of his father to the latter place, he became a student in Pennsylvania College, and was graduated there in the year 1839, in a class of fourteen members, most of whom are now deceased,

As the bud conceals within itself the beauty of the future flower, so do the unfolding powers of the youth foreshadow the direction, and extent of the excellence of the fully developed man. From personal recollections, but chiefly from letters from some of his yet surviving classmates, and intimate friends, we can say something of the peculiar traits of character he exhibited when he was a student in college, or in his boyhood; for he was still a boy, at least in years, having become a college graduate, when he was but sixteen years of age.

The writer spent one session of a collegiate year at Gettysburg, fifty years since, with him whose earthly career has so recently terminated in such golden radiance. He cannot speak very confidently of him at that time, for in consequence of being older in years, and having removed to another institution, he was but seldom thrown into his society. Memory, however, still retains the image of his personal appearance, a frail, attenuated form, apparently destined to a brief period of existence. He is not able to speak, from his own personal knowledge, of his intellectual peculiarities, for the reasons already mentioned, and because, at that period, when he was about ten years of age, they had not yet been sufficiently displayed to form any satisfactory judgment. He can affirm this much of him, that he never thought at that time that he was destined to survive long, or to attain such extended and deserved fame in letters.

The writer's deficient knowledge is fully supplemented by letters which are before him, of his fellow-students and classmates, in which he is graphically presented to us, as he appeared to them. One of these, now a Doctor of Divinity in the Presbyterian Church, speaks of him, "as having inherited some of his father's easy-going disposition, but capable of great passions, and great efforts," "fond of fun," "an inveterate punster," "sarcastic," having "a ready and comical trick of exaggeration," a great lover and declaimer of Shakespeare, and of large literary culture. Another classmate, the Rev. Dr. Charles Hay, of the Lutheran Theological Seminary at Gettysburg, in a letter to the writer, in which he says, "they were boys together, and bed-fellows for a year," speaks of his departed friend in the most kindly manner, and gives a very satisfactory account of his whole student life. The whole letter would be useful in print, but the limits to which we have to confine ourselves, will allow us only to quote so much of it as will be sufficient to give us a clear idea of his intellectual peculiarities at that period of his life. He remarks: "The cast of our brother's

mind was metaphysical. He delighted in the English studies of the college course (with the exception of mathematics), and in these easily distanced his seniors, some of whom numbered twice his years. He was a voracious reader, devouring with avidity almost every thing that he could lay his hands upon. Thus absorbed, he became oblivious to the lapse of time, and was frequently, we may almost say, habitually negligent of the proper preparation for the regular recitations. * * * His mind worked with amazing celerity, and his fund of general information was remarkably extensive in one so young. * * * The drudgery of routine was always distasteful to him, and he had often, in the recitation room, to be aroused from a reverie, into which his poetic fancy had led him away, as into the dreamland, where he loved to linger. With a keen sense of the ludicrous, he seemed unable to resist the temptation to make sport of the unfortunate weaknesses and blunderings of the less active minds around him. The youngest in a large class * * * he found abundant opportunity for the display of his lively wit, which, with all its native kindliness and playful geniality, was sometimes the reverse of welcome to those at whom it was aimed." Those who had constant opportunities of seeing Dr. Krauth in his subsequent life, will recognize the coincidence of this accurate portraiture of his early life with the features of character he displayed, almost to his dying hour, the only difference being that they were placed more under the control of reason, and their rough edges had been removed "by his native kindliness," made more kindly, by continual advances in Christian principle and love.

His collegiate career was now closed, and it was necessary for him to decide upon a profession, in which he might more usefully employ his native and improved capacities. I do not think he was long in coming to a conclusion; for two years before his graduation, in connection with the dear friend already named, he had determined to devote himself entirely to the service of the Redeemer, and had been admitted, by the rite of Confirmation, to the communion of the Christian Church. On the occasion when these two interesting youths made up their minds to take this decided stand, Dr. Hay remarks that the elder Dr. Krauth, intensely interested for the welfare of his son, made a most fervent prayer in their behalf, and he gives his conception of it, by exclaiming: "Such a prayer!" And the same thing is alluded to by another, well acquainted with the facts, who remarks: "Many there are who will never forget that prayer. * * * A prominent lawyer in the State, and an elder in the Presbyterian Church, ascribes his usefulness to the influence of that prayer." The elder Dr. Krauth was inimitable for the fervency and pathos of his supplications on all occasions.

This first determined step of the son on the side of Christianity, in connection with the instructions, wishes and prayers of his venerated father, prepared the way for the second, the devotion of himself to the church in the ministry of the gospel. The loving father of our lamented friend experienced greater joy, without doubt, in this determination of his son

to devote himself to the holy and responsible office of the ministry, than did Philip, of Macedon, when he counted himself happy, not so much on account of the birth of a son, as because he had an Aristotle to conduct his education. Acting in accordance with this purpose, the subject of our notice entered the Theological Seminary of the Lutheran Church, at Gettysburg, as student, and finished his theological course, in the Institution in which his own father was one of the professors, in the year 1841, and first was licensed in the same year to preach the gospel by the Synod of Maryland; and then ordained, by the same ecclesiastical body, to the holy office of the ministry, when he was but nineteen years of age.

The preparatory stages of his education are now over, and he enters into the arena of conflict. Nearly one-third of his life, as we now know, had been passed in the work of preparation; the remaining two-thirds were to be spent in more active efforts for the good of others; in the further development of his powers, and in extending his studies in new and more difficult fields of intellectual toil. As we intend to contemplate his successful efforts, during this latter period, as preacher, editor, theologian and philosopher, as well as his estimable qualities as a man, we regard it to be both useful and necessary, before proceeding with the consideration of the topics, to give a condensed summary of the facts with reference to the positions he occupied, whilst discharging these different offices.

His regular *pastorate* of Lutheran churches extended from 1842 to 1868; at Baltimore from 1842–47; Martinsburg, Shepherdstown and Winchester, successively from 1848–55; Pittsburg, 1855–59: St. Mark's, Philadelphia, 1859–64; St. Stephen's, in the same city, 1866–68, including ten months spent in the islands of St. Thomas and Santa Cruz, West Indies, and a short temporary service at St. John's Lutheran Church, Philadelphia, in the absence of the regular pastor. Though not a regular pastor after this period, he continued to preach, when requested, throughout his life. He was elected "Norton Professor of Systematic Theology and Ecclesiastical Polity," in the Lutheran Theological Seminary at Philadelphia, in the year 1864; "Professor of Intellectual and Moral Philosophy" in the University of Pennsylvania in 1868; Vice-Provost, in 1873; the subject of Logic was added to his chair in 1874, and that of History in 1881; and these positions he held with distinguished ability until his death.

Besides these positions as professor, he was editor of the "Lutheran and Missionary," from 1861–66; Trustee of the University of Pennsylvania from 1866–68; President of the General Council of the Lutheran Church 1870–80. He was likewise a Member of the Oriental, Philosophical and Historical Societies of this State; and also of the Committee for the Revision of the Scriptures. In each and all of these important positions, his profound learning and wisdom were eminently useful, and greatly appreciated by his distinguished associates.

A few particulars, of a more private nature, are here also added, to give this part of our sketch completeness. He was twice married; in 1843, to Miss Susan Reynolds of Baltimore; and in 1854, to Miss Mary Virginia

Baker, of Winchester, Va. The degree of D.D. was conferred upon him, by Pennsylvania College, in 1856; and that of LL.D., by the same Institution in 1874. He spent the summer vacation, in the year 1880, in Germany; gathering information, and visiting places, for a Life of Luther, which he had been requested, by the Church to which he belonged, to prepare; but which we deeply regret he did not live to complete; the same period in the summer of 1881, he was visiting Canada, for the benefit of his health, during which time he wrote his, "Cosmos," the last one of 1882 he was at Mt. Desert Island, on the coast of Maine; and his death occurred, January 2d, 1883.

It will be seen, from the preceding particulars of his life, that his labors were divided between two professions, often either permanently, or temporarily conjoined, in aim and usefulness closely allied with each other, that of the ministry and professor in institutions of learning and religion. Whilst our friend had qualities of mind and heart to make him useful, in either of these professions, he frequently informed me, that he much preferred the chair of the professor to the pulpit. Nor was this owing to the fact, that his pastoral labors and pulpit efforts had not met with the approval of the people, or had been wanting in success; but because he believed, that the sphere of influence for good was wider in the former, than in the latter.

We know, from the best evidence, that both in the country, as well as in the city, in the congregations he served, he was highly honored for his ability in the pulpit; and greatly esteemed and beloved for his personal character. With increase of years and experience, he gave increasing satisfaction, and acquired additional fame. A few, it is true, found fault with the peculiar tones of his voice, and peculiarities of attitude, in his early ministry; and some, at a later period, with the labored character of many of his written discourses, but his greatness was generally recognized.

These slight defects of manner disappeared with increase of years, so that the tones of voice and mode of delivery became agreeable, and little open to censure. He preached both with, and without a manuscript. His written discourses displayed more fully his imaginative power, beauty of expression, and the depth and extent of his learning; but his unwritten ones, the pathos and force of the eloquent orator. When he spoke without notes, his words were, like those of his excellent father, who always used this method of preaching, for the pleasure and edification of the people. It was then, that "the common people heard him gladly," whilst his written discourses were better adapted to a higher grade of hearers. The latter class of auditors were carried away with admiration for his learning and great ability; whilst the former were instructed and deeply moved, by the glowing words which welled forth spontaneously from his loving heart. The writer recalls to mind four separate occasions, especially, when he had the pleasure of listening to his preaching. The earliest one was in the year 1864, during a rebellion of the students in Pennsyl-

vania College, against the Faculty of the Institution, on account of dissatisfaction with the distribution of college honors. The theme selected by the speaker, on this occasion, was the conduct of Rehoboam, in listening to the advice of the young men, instead of being guided by the counsel of the more aged, whereby the kingdom of Israel was rent into two parts. The subject was handled with such excellent judgment, and great power, that its effects were very marked upon the minds of the intensely excited youth; and contributed largely in bringing them again under the control of reason and Christian principle. Another very elaborate sermon, on the distinguishing peculiarities of the Lutheran Church, marked with all the profundity of thought, copiousness of illustration, vigor and beauty of expression, which are found in his written and printed sermons, the writer heard with great satisfaction, on two separate occasions; when it was listened to and admired by the large audiences, before whom it was delivered, with enraptured attention. The last two, however, which were delivered without notes, and without much previous preparation, made the greatest impression upon the mind and heart of the writer; one, descriptive of the mission of the Saviour, based on the passage: "He went about doing good;" the other, within quite a recent period, explanatory of the verse: "the whole creation groaneth and travaileth in pain together until now." This was a grand effort, and was upon a subject which seems to have been, at this period of his life, a favorite one with our departed friend, for it is alluded to in one of his last literary publications, the "Cosmos," in the two following stanzas:

"Yet the world we may not love,
Melts into a happier day,
When at God's transforming word
Sin and death shall pass away.

Oh, for that transcendent change
Which her bridal shall recall,
And with robes of spotless white
Cover o'er her crimson pall."

There are, lying before me, quite a number of his printed discourses, sermons and essays, in volumes appropriated to such literary productions, belonging to different periods of his pastoral life; they all present the same general features of excellence, and defects. They are full of inventive and imaginative power, display great extent of reading and profundity of thought, but sometimes, owing to the neglect, perhaps, of mathematical study during his collegiate course, are deficient in perspicuity, by a too abundant accumulation of particulars, or variety of illustrations. This characterizes more especially his earlier writings; after he turned his attention more fully to philosophical study, there is a marked improvement, in precision of statement, perspicuity and terseness of expression. Our limits will not allow us to quote any passages in proof of our assertion.

The *pastoral* life of our fellow-member prepared the way for his profound studies, as a theologian and theological professor. Circumstances

might have so influenced him, as to have conducted him on to the further cultivation of the imaginative and poetic element of his nature, as it was manifested in his collegiate life, and in his first sermons; but he was led by what we might call an accident, but which, no doubt, was the providence of God, to the more complete improvement of the rational faculty; and then he was turned aside into the domain of logical and speculative theology. In the list of his published writings, during the period from his ordination to the ministry, to the time of his election to the theological professorship, numbering twenty-six, more than half of the entire number are profound papers on theology and psychology. In one of them, written in 1858, which contains an account of the bibliography of the Augsburg Confession, there are twenty pages of the "Evangelical Review," taken up with the list of titles of books on the subject, one hundred or more in number, all, or most of which, he had in his own library. He must have had at that time, the idea in his mind, for some reason or other not known to us, that he was to be distinguished as a theological professor; and with a view to this, had already commenced collecting that valuable library, in this special department, which at his death amounted to 14,000 volumes, and had cost him $30,000. Many of these papers, on the, "Relation of the Confessions to the Reformation;" the "Lord's Day;" "The Mass;" "Liturgies," &c., were modified, improved, and inserted with his latest views, in his greatest and best book: "The Conservative Reformation," which first appeared in the year 1871.

How this particular direction was given to his studies, we are taught by one of his friends, whom we have already quoted. He remarks, that he asked on one occasion, the elder Dr. Krauth, how his son, "the poet and preacher," was changed into "the theologian and controversialist," and he replied, that it was owing to the fact, that he had presented to his son "Charles," a copy of Chemnitz, who was a distinguished Lutheran theological champion, in the era of the Reformation, against the dogmas of the Roman Catholic Church, as laid down by the Council of Treat. This, so far as known to us, was the first stimulus given, for the intensified development of his native turn, for speculative truth. The same kind of studies was pursued, and the same kind of writing continued also during the five years, from 1861 to '66, whilst he was editor of the "Lutheran and Missionary." And though the poetic vein often re-appeared in him, in all the subsequent years of his life, and was exercised in the composition of fugitive pieces of poetry, either original or translations, the burden of his work was of a controversial character, on the subject of liturgies, divergencies of theological belief and kindred matter, during all this time. These discussions were conducted with amazing skill and learning, and with a wit and power of expression, sometimes tinged with severity, unequalled in the Church; and which always silenced, if they did not convince, those who were opposed to him. His words, during the heated controversies, which prevailed in the Lutheran Church in America, in the five years of his editorship, were like the arrows, sent into the Grecian

camp, by the "god of the silver bow." Hundreds of such polished shafts were sent, with convincing and controlling power, during each week of the period of his editorship of the "Lutheran and Missionary."

Brought thus to the front, by his studies, and his positions of influence, he was not long in realizing the dream of his early ministerial life, if we are right in our supposition, for in the year 1864, he was elected to the position of "Norton Professor of Systematic Theology and Ecclesiastical Polity," in the Theological Seminary of the Lutheran Church, in Philadelphia. He had now ample time and opportunity for exercising his skill in theological dialectics. Additional articles of the same kind were published, with those which had appeared at an earlier period; and the culmination of his work in this department took place, when he prepared and gave to the world, in a grand volume, his "Conservative Reformation," to which allusion has already been made.

This volume demands more than a passing notice, for it is the noblest monument of his vast theological learning and dialectical skill, immense acquaintance with the whole field of literature, and of his intense love for the faith and church of his forefathers. Besides this, it has other points of interest. One of these is stated by the distinguished author himself in the preface. In the Lutheran Church, both of the Fatherland and this country, there have always been two parties; one more liberal in the interpretation of the Confessions; the other more strict, allowing no deviation, in the smallest particulars, from the standards of belief. The Doctor, with great candor, acknowledges, as is known to most of the older ministers of our Church, that he once occupied a position entirely divergent from the views he defends, in this splendid volume. Thus he speaks: "No man can be more fixed in his prejudice against the views here defended, than the author himself once was; no man can be more decided in his opinion, that those views are false than the author is now decided, in his faith, that they are the truth. This decided change from laxity, to strict conformity with the old Lutheran faith, as it is sometimes called, was permanent with him, and he maintained it with unvarying consistency, until his departure from the Church Militant to the Church Triumphant. Again, the author shows that he has changed his views with sufficient reason, for all the prominent doctrines of the Lutheran Church, as presented in the Augsburg Confession, are discussed with great skill and independence of judgment, and in connection with this chief symbol, the subsequent ones are not overlooked. It is a complete defence of the whole system, with that independent survey of the field for himself, for which the author was noted, for he could truthfully quote, as applicable to himself, the sentiment of the Roman poet: "Nullius addictus jurare in verba magistri."

The subjects of Baptism, Original Sin and the Lord's Supper, receive the most extended and varied discussion, because the most difficult, and the most frequently assailed by others. It is not generally known, that

the Lutheran Church has a mode of presenting these subjects, in her judgment in accordance with the Scriptures, which require careful and discriminating study to understand, as is sufficiently proved by the mistakes into which men of the highest ability in some of the other Christian denominations have fallen, in the attempt to state them as they understand them.

The mode of the Saviour's presence in the Supper; the doctrine of the "communicatio idiomatum;" the union of natures in the person of the Redeemer and consubstantiation, which the Lutheran Church is said to hold, but does not, have especially been the occasion of the grave mistakes made by the gentlemen to whom reference has above been made. They are known and believed by those only who have been brought up in the Lutheran Church, but they require profound acquaintance with the subject, and native and philosophical acumen, to defend them against objections, without falling into error. In this field, difficult though it be, our friend showed himself a complete master, and the careful study of these profound subjects is visible on every page. The volume contains several elaborate chapters, prepared years before, designed specially to correct the mistakes made on the above subject, by learned Doctors of Divinity in sister churches.

The chapter also, on the history of the "Formula of Concord," which was prepared at a later period than some of the others, is exceedingly well fitted to show the solid theological learning, superior penetration, and independence of judgment of our gifted and diligent associate. It amazes me whenever I read it, to see how he unravels the tangled history of the theological controversies which agitated Germany, during the latter part of the sixteenth century, and how he follows, with clearness of intellectual vision, the intricate thread of truth, with which he started, to its final issue in the adoption of this Symbol. It pleases me to find, that he does not condemn, where others bitterly condemn "the gentle Melanchthon;" who had, by his laudable, though sometimes mistaken desire for peace and aversion to controversy, given occasion to some of those acrimonious disputes. Yet, with all his high regard and esteem for this fine scholar and excellent man, he is not blind to his faults, but censures him when he thinks him deserving of it. It is easy to see that the writer is guided in his judgment by the love of truth, and not by prejudice, and Melanchthon fares better in his hands, than he does with many of his own countrymen and contemporaries. This was a fine field, for the exercise of that "speculative" mind, with which Providence had endowed the author of this volume, and which is displayed in it, with such happy results.

The independence of our able friend is shown also in an article, which he prepared during his ministerial life in the year 1857, on the Lord's Day, which does not appear in this volume, but which must be alluded to, because in it he expresses and defends views which do not harmonize with

those of many of the German theologians, but which he defended, as in accordance with the teachings of Luther and the Confessions, and which he continued to hold, as he informed me near the end of his life. We are not able say why it was not published with the others, possibly he did not think it necessary to put it into this more permanent form. Some of the German theologians so explain disconnected statements of Luther, without taking them as a whole, that they dissipate altogether the divine obligation with reference to the observance of the Lord's Day. Not so our friend. We allow him to speak for himself. "If Germany has not enjoyed a Christian Sabbath, it is because she has refused to follow what the principles of Luther would have given her. The Sunday of Luther is an entire day, not a half-day; not a morning for the church and an afternoon for the beer saloon or the dance, or the idle saunter; but a day for holy works; and holy thoughts; a holy day, not a holiday. Neither the Augsburg Confession, nor the greatest theologians of the Church of the Augsburg Confession, denies the divine obligation of the Christian Sabbath. * * * Divine in its generic origin and obligation, and apostolic in its specific determination."

There is one delightful chapter of the book which has but little of a controversial character in it; it is a solemn requiem of praise in honor of Luther, from almost every land of Christendom. The instrument selected by God, for the great work of the Reformation, is the hero, who has caused their strings to vibrate, in such perfect unison. No where else can there be found such a collection of literary gems, bearing upon this one point. The writer's soul was aglow with admiration and love for Luther, when he wrote this admirable chapter, and after the full array of testimonies of the most illustrious characters in his behalf, he closes the subject with these striking words: "Luther abides as a power for all time. His image casts itself upon the current of ages, as the mountain mirrors itself in the river at its foot—the mighty fixing itself upon the changing."

We may safely say, in passing from this volume, to the consideration of his last publications on another subject and in a different sphere of his useful and honorable toil, that no one can read it without reaching the profound conviction that the author of it will bear favorable comparison with the ablest theologians of this or any other land. Little else can be said of it, except to express admiration of its merits; if we may be allowed to say anything of a contrary nature, we would merely respeat a remark already made, with reference to some of his earlier writings, that his logic occasionally is wanting in perspicuity, from an excessive accumulation of particulars, and now and then he exceeds the bounds of truth by indulging that vein of his complex nature, alluded to by one of classmates, "a ready and comical trick of exaggeration." A single illustration will sufficiently explain our meaning. Thus he speaks of sects: "The insect-minded sectarian allows the Reformation very little merit, except as it prepared the way for the putting forth, in due time, of the particular twig of Protest-

antism, on which he crawls, and which he imagines bears all the fruit, and gives all the value to the tree. * * * The Reformation, as they take it, originated in the divine plan for furnishing a nursery for sectarian Aphides."

His native fondness for speculative truth, together with his studies in connection with theology, which, from the standpoint he accepted, almost necessarily involved the study of philosophy, prepared the way for his last position, Professor of Intellectual and Moral Philosophy in the University of Pennsylvania, to which he was elected in the year 1868; the subject of Logic having been added to it in 1874. In some of the articles of the "Conservative Reformation," he shows his large acquaintance with the foremost philosophers of the English and Scotch schools, such as Mill, Hamilton and others; and his fondness for studies of this kind, led him to publish an edition of Fleming's Vocabulary of Philosophy, eight years before he was elected to the post of professor. If we mistake not, the attention of some of the Board of Trustees was first directed to him, on account of his prominence among the Lutheran pastors in Philadelphia, and thus he was elected trustee in 1866, to represent the Lutheran Church, and the ability there displayed, and the acquaintance made with its members, and especially with Dr. Stillé, the Provost of the Institution, to whom it owes so much, his warm personal friend, shortly afterwards elevated him to the responsible position he occupied in it, which, with other additional duties and offices, he continued to discharge and to hold until his death.

The department of Philosophy was the chief one, in which such volumes as Hamilton's Metaphysics, Berkeley's Philosophy, Whewell's Morality, Butler's Analogy, constituted the text books, which made the basis of his instruction, and through which he exerted a wide and lasting influence on his pupils. For the use of his department he edited Berkeley, and enriched it with notes of great value, from all the different schools of philosophy among Christian nations, which appeared in 1874; and at the same time republished in the same way, with a very learned introduction, Ulrici's Strauss. Through these publications, and his lectures to his classes, from year to year, his reputation as a philosopher became as great in our land as in the department of theology. He was frequently appealed to as the highest authority in questions of a philosophical nature, and it was easy to anticipate from the instructions of his able and excellent father, and his own subsequent studies in theology, what position he would take in this vast and intricate field of speculation. These two things dominated his views. Philosophy had been settled in his theological studies, for we find the principles of Butler, Berkeley and Hamilton, presenting salient points in these earlier investigations. He was, as we might have expected, from such antecedents, an "Idealistic Realist," to quote the words of one of his favorite pupils, who understood well his views, and a philosopher of decided Christian character. It was his great aim to infuse these principles into the minds of the students of the University whom he instructed in successive classes for almost fifteen years, and upon whom he left the

indelible marks of his power and varied learning. He has left behind him no regular system, and this is a matter to be regretted, except so far as it can be gathered from his annotated works, and the notes and recollections of his pupils. These, with his favorite authors, in this department, will always show us the genuine Christian philosopher. Butler's Analogy was one of his favorite books, we see its principles brought out in his discussion of Original sin; in his Introduction to Strauss and in his last poetic effusions, and we are gratified to quote his own words on this subject, to this effect: "that he regarded this as a monument to the truth of the Christian religion, which shall endure to the end of time."

The edition of Ulrici's Strauss, which he superintended, translated and furnished with an introduction, is a work of immense practical value. It is small in form, but on this account, not less, but more valuable. Ponderous volumes, like heavy artillery, are hard to manage, and have but few readers, but the smaller ones, which you can take with you to the fireside, are popular and effective with the largest number, like the small arms in the close and well-contested battle. The reader of the introduction contemplates with wonder the immense, almost boundless extent of the author's reading in physiology and philosophy. As he was regarded and called in early life a "voracious" reader in literature and the department of the imagination, so his appetite in later life was equally insatiate in physiology and philosophy. He seems to have sounded with his plummet the subject in its profoundest depths, and widest extent, and after all his studies he remains the Christian philosopher still. It is gratifying to find a gentleman of such breadth of culture, defeating, on their own soil, and with their own weapons, the enemies of truth, of God and of man. He is, in his own peculiar style, severe on materialism, and still more severe on Strauss, the great advocate of infidelity and atheism. Speaking of the union of the supernatural, everywhere with the natural, in Butler's line of thought, but his own words, he says: "Science moves ever toward the proof, how supernatural is the natural; religion moves toward the proof, how natural is the supernatural. For nature, in the narrow sense, is in her spring, supernatural." To expose such a system as materialism "would involve the compression of a world to the dimensions of a pea." "Without the metaphysical spirit, the geologist possesses the penetration of an artesian auger, no more." "The intellectual beats the material in all long races." The "new faith" of Strauss is characterized "as conscious matter, reverencing and worshiping unconscious matter," "as reason bowed at the altar of unreason, which had given it being;" as "without God, without Providence, without spirit, freedom or accountability;" "recognizing no creation or redemption or sanctification;" "no heaven, no hell, * * * whose last enemy is not death, but immortality, its goal, extinction." These and a long list of other features, severely yet truthfully present, in the language of the author, the repulsive deformity of this proposed "new faith."

The volumes, on which the Doctor's fame will chiefly rest, are the three

which have been mentioned. "The Conservative Reformation;" "Ulrici's Strauss" "Berkeley, with Notes," and the translation of "Tholuck's Gospel of St. John." Through these, with the many and varied essays, articles for encyclopædias, editorials, lectures at the Seminary and University, sermons published or heard, and the large number of young men whom he helped to educate for the ministry, the other learned professions, and practical life, will cause his influence to be felt, for good, through all future time. Throughout the forty years of his very active and laborious life—had he lived, forty years this day—in imitation of the Great Teacher, "he served his generation faithfully, according to the will of God," and he will be held in everlasting remembrance, as one of the great benefactors of the race.

Our subject would be incomplete, did we not speak of his excellent qualities as a Christian man. Scholarly acquisitions are often tarnished, by moral, or personal defects, or obliquities. It was not so with our friend. The grand elements of his character were harmoniously united, with a natural simplicity, and an affluence of kindly feeling. He was very condescending towards inferiors, and extremely fond of children, whom he could most successfully entertain and instruct. In his addresses to them he laid aside all that was repulsive, became one of them, disarmed all their fears, and attracted them to himself. Nor was this attractive power limited to them; it was general. The extent of it was realized fully since his lamented death. Friend and foe, the aged and the young, those of the same belief with himself, as well as those who occupied positions in theology directly opposite to his own; officers of the churches he served, and gentlemen associated with himself in public bodies, have, with great unanimity, testified both to his general excellence, as well as the warmth of heart, by which he drew them to himself. One, eminent in position, but often opposed to him in debate, speaks of him as "cordial, genial, magnetic and brilliant, often winning his way to hearts that were closed to others, and forming personal attachments which no changes of time or circumstances could break." Such a man could not fail to be respected and beloved.

But the bowstring, after long use, when subjected to extraordinary tension, will snap asunder. So it was with our departed friend. There is a limit to human exertion, and our bodies and minds will not endure indefinite pressure. The superabundant labors, apparent in what we have said, but more fully known to his associates, together with the anxieties, sorrows, disappointments—greater, because kept to himself—which his friends knew but did not venture to allude to, out of regard for his feelings, by degrees brought his manly form to an early grave. We will not draw aside the veil which conceals these special troubles from the public gaze, to which he never himself made any allusion, except to say, "the heart knoweth its own bitterness." They are too sacred for publication, but they exerted no little influence in gradually undermining his vigorous health. The first intimation of any serious illness was communicated to the writer by a friend of the Doctor, who visited Germany with him, and

was his almost constant companion for three months. The next communication was made by his family physician, who remarked at that time, that the only relief for the Doctor would be total cessation from work, but that mode of relief his multiplied engagements, and his conscientiousness did not allow him to adopt. He acted, as far as possible, in accordance with the advice of the physician, and spent the two succeeding long vacations of the years 1881 and 1882 in Canada, returned with his health recruited, but when his double duties in the two Institutions in which he was engaged, were resumed, he again lost ground, and it was apparent that the disease was preying on the vitals of his system. On his return from the last trip, in answer to a question of one of his friends as to his health, he replied with sadness, as though looking forward to an unfavorable result, "better, but not well." The truth of this became painfully manifest when he resumed his duties in the University. He was very far from being well. His associates soon observed that his vivacity and vitality, and his powers of endurance were rapidly decreasing. Especially marked was this decline in the daily chapel services. Each succeeding day, through increasing weakness, he brought his chair nearer to the reading desk, until the day before he was ordered by his physicians to relinquish all his duties, they were placed alongside of each other, and it was with difficulty he could stand up to perform the devotions. With such Christian fortitude did he continue to discharge his duties during the progress of the disease to its final issue. His principles would not allow him to forsake his post, until his powers were exhausted.

The writer now believes. the Doctor was fully conscious of his approaching dissolution, for he could not take sufficient nourishment to support life, and, besides this, the tenderness and deep pathos of his prayers, whenever allusion was made to death, disclosed the thoughts and feelings within. The writer conversed with him, for the last time, the day before he completed his official duties. He bade farewell to him, as he thought, for a few days, in front of the University, at the close of the recitations for the day; it was with difficulty that he moved his exhausted body, yet the writer will never forget the almost angelic tenderness and sweetness of his language and his looks.

Two days after this he was ordered by his physicians to take his bed, and, contrary to the expectations of all, he declined more rapidly than before, and two weeks subsequently, when the new year 1883 had but commenced, January 2d, amid his sorrowing friends, without much suffering, his noble spirit, sustained by the faith and hopes of the Gospel, was conveyed to the bosom of his Saviour, whom he had loved and served so well.

The removal of such a man must be deeply mourned, for his place cannot readily be filled; but we may comfort ourselves with the thought, to which the Provost of the University gave utterance in the chapel, two days after his death, that as he was suffering from an incurable disease, he could do no more on earth, his work was done, and well done, he had secured

the victor's crown. We recall to mind, at this point, the distinguished Grecian philosopher, Socrates, surrounded by his weeping friends and pupils, whom he was reproving for their sorrow, and endeavoring to console with his own joyful hopes for the future world as he was bidding them farewell; and we can thus think of our Christian philosopher addressing us, from the glory he has attained, in words used by himself, many years ago, in some reflections on the Transfiguration: "Why do we think of the parting pressure of the hand, the last words of love, the dying moan, and not of the crown, the communion with Christ, their eternal repose, and our re-union with them? Why, with desolate hearts, will we continue to stretch our hands to the home of their rest and cry, come, come to our arms? Blessed be God, that he will not hear our prayers. Blessed are the departed, that we cannot recall them from their joy, or wound their hearts by the knowledge that we are willing to disturb their bliss. No, it is not good to be here; we know not what we say."

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*Fourth Contribution to the History of the Permian Formation of Texas. By E. D. Cope.**

(Read before the American Philosophical Society, March 16, 1883.)

PISCES.

ECTOSTEORHACHIS CICERONIUS, sp. nov.

The genus *Ectosteorhachis* Cope, is known up to the present time from ichthyolites, which do not exhibit the interior details of the structure of the skull. Several portions of crania having recently come into my hands, I am able to add some important features, and a new species, which I name as above.

The base of the skull consists of ossified parachordals, which embrace the chorda dorsalis posteriorly and are continued for a short distance posteriorly as a tube. Anteriorly the chordal groove is open. Trabeculæ not ossified. The cranial structure is an excellent illustration of a permanent embryonic type. Above and in front of the opening for the chorda, the neural canal enters the groove. The parachordals are subtriangular, presenting one angle forwards, and having the internal side that bounds the groove straight and longitudinally grooved. The anteroexternal side is oblique and nearly straight, and is overhung by the osseous roof of the skull. These characters are identical in both species.

The *E. ciceronius* differs from the *E. nitidus* in having a narrower interorbital region, and in the possession of small tubercles of ganoïne on the posterior parts of the superior surface of the skull. These are seen on the sides of the surface, and are quite small, not numerous, and

* The third contribution can be found at page 447 Proceedings of the Society for 1882.

of various sizes and shapes. They resemble shining seeds. In *E. nitidus* these points are wanting, but there are rugosities on the postfrontal and pterotic regions of a radiating character, not found in *E. ciceronius*.

Measurements.	M.
No. 1.	
Length of skull to occiput above (muzzle worn)	.069
Interorbital width	.014
No. 2.	
Length of osseous base of cranium (parachordal)	.039
" open median groove	.022
Width of base at parachordals	.036
" groove at apices of parachordals	.011
" foramen notochordæ	.0095

Found by Mr. W. F. Cummins.

GNATHORHIZA SERRATA, gen. et sp. nov.

This presumed fish is represented by some teeth which are processes of osseous bodies, which may be roots properly so called, or may be jaws. The osseous bases are shallow, and thickened on the free edge, which is directed obliquely away from the plane of the crown of the teeth. The teeth obtained are flat, and doubtless bilaterally symmetrical, though no complete pairs are preserved. The largest of these has a curved edge, and a branch extending posteriorly at right angles to it, joining it at a point at one side of its middle. The longer (and more curved) part of the convex edge, has two coarse angles; the shorter part is finely denticulated, as is the transverse lamina. The principal edge is worn posteriorly by use. The external convex face is marked by coarse and finer lines of growth, like those on corneous processes. A second form of tooth is not curved, but flat, so far as preserved. It has three coarse obtuse teeth. Two other toothed bodies resemble it. All the teeth are covered with brilliant ganoïne on both sides.

Measurements.	M.
Length of chord of larger tooth	.010
" cross lamina	.0055
Elevation of principal edge	.006
" with root	.008
Thickness of root at base	.002

The genus *Gnathorhiza* may belong to the Petalodont family, though I think it very doubtful. The characters of the roots of the teeth are more like those of sharks.

BATRACHIA.

TRIMERORHACHIS BILOBATUS, sp. nov.

Among the many specimens of animals of this genus which have passed through my hands, I have not until now been able to select more than one

species, the *T. insignis*. Mr. Cummins, however, now sends me parts of skeletons of four individuals, which present distinctive characters. Two of these include vertebral elements, and all embrace jaws and bones of the limbs and arches.

The vertebræ present no important difference from those of *T. insignis*, but the surface of the intercentrum is not yet cleaned of a thin layer of matrix. The peculiar character of this species is most readily seen in the posterior portions of the mandibular ramus. The angle consists of two subequal tuberosities which are separated by a deep groove, instead of one prominent one. The external tuberosity is represented in the *T. insignis* by a small protuberance of the lateral enlargement of the external face of the ramus. The extremity of this tuberosity is in the *T. bilobatus* strongly honeycombed, and it is bounded below and externally by a groove which is faintly indicated in *T. insignis*. Above it, on the inner side, is another, shallow groove, from which it is separated by a sharp ridge. Both grooves are smooth. The superior one is wanting in *T. insignis*. The quadrate cotylus is more depressed externally than in *T. insignis*, thus making it more oblique. The internal fossa of the cotylus is not divided by a longitudinal groove, as it is in *T. insignis* The dental foramen is large, and is located as in the *T. insignis*. There is also an inferior longitudinal groove of the ramus as in that species. The surfaces preserved show that the sculpture is more marked in the *T. bilobatus* than in the *T. insignis*.

Measurements.	M.
Depth of ramus at interior edge cotylus	.026
Length " from " " "	.020
Width " at " " "	.017
" of both tuberosities of angle	.0125
Diameters of intercentrum { anteroposterior	.011
Diameters of intercentrum { transverse	.021
Thickness of intercentrum	.004

The specimens described came from the same locality, and a different one from that which has produced the specimens of the *T. insignis* (Type No. 39, 1882).

REPTILIA.

PARIOTICHUS MEGALOPS, sp. nov.

This reptile is known to me from a nearly complete, somewhat distorted cranium. A thin layer of matrix conceals the greater number of the teeth, so that the presence of canines cannot be demonstrated. Those which are visible are on the premaxillary and anterior parts of the maxillary bones. They are small, conic, slightly curved, acute and absolutely smooth.

The muzzle is short and broadly rounded. The nareal opening is laterosuperior, and is just above the principal convexity where the lores pass into the muzzle. Canthus nostralis rounded off. Interorbital region wide, convex in section, nearly plane anteroposteriorly, its width a little exceeding the diameter of the orbit. Orbit large and round, its diameter equal to

the length of the muzzle in front of it, obliquely measured, and one-half the distance from its posterior edge to that of the temporal roof (? squamosal bone). Posterior outline of skull above, truncate, surface slightly convex transversely.

The premaxillary spines are short and wide, the nasals are also short and wide. The prefrontals and postfrontals form the superior edge of the orbit, excluding the frontals. The intercalaria (or ? pterotics) are very large; at the externoposterior angle is a very small element in contact with the supraoccipital which may be the true intercalare. The supraoccipitals have considerable transverse extent, running out externally in narrow apices. All the bones of the cranium are sculptured in honeycomb fashion, the ridges radiating on some of the bones. That is, on the posterior parts of the frontals and parietals and anterior part of the intercalare and squamosal. A groove follows the edge of the orbit, and turns inwards on the prefrontal bone, forming a rudimental lyra. External surface of mandible grooved below; superior part concealed.

Measurements.	M.
Width of skull between posterior angles	.018
Interorbital width	.008
Axial length of skull	.024
" from muzzle to between centres of orbits	.0096
Width of muzzle at nares	.0095
Length from orbit to nostril	.0035
Depth of skull posteriorly, to mandible	.010

The superior part of the posterior region of the inner face of the dentary bone supports a patch of small obtuse teeth, which narrows forwards into the single row of the edge of the ramus. This patch is no doubt homologous with that which is so largely developed in *Pantylus*.

The surface of the cranium has been mostly weathered away in the type of *Pariotichus*, *P. brachyops*, and I suspect that it is really sculptured and not smooth, as I originally stated. The *P. megalops* differs from the *P. brachyops* in the larger orbit, the narrower interorbital space, and the smaller and more numerous teeth.

Pariotichus and *Pantylus* and probably *Ectocynodon* must be referred to a special family, the *Pariotichidæ*, which has teeth like the *Edaphosauridæ** but differs from it in the entire overroofing of the temporal fossæ.

CHILONYX RAPIDENS Cope, gen. nov.

Char. Gen.—Teeth with the long diameter of the crowns transverse to that of the jaws, and with the crown contracting to a single slightly incurved apex. Maxillary series of teeth short. Temporal fossæ overroofed. Superior surface of cranium divided into more or less swollen area by grooves.

The characters above enumerated indicate for this genus a position near the *Diadectidæ*. From these it differs in the form of the teeth, and the

* Proceed. Amer. Philos. Soc., 1882, p. 450.

short and narrow maxillary bone. Two ilia accompanying the cranium have the form of those of the *Clepsydropidæ*, and differ entirely from those of the *Diadectidæ*. On the other hand, the *foramen magnum* is wide, and the exoccipitals present two articular facets downwards as in the latter family. It is possible that the genus should be referred to the *Bolosauridæ*, which is in dentition intermediate between the *Clepsydropidæ* and *Diadectidæ*.

A femur, which is included in the lot of specimens, has a wide head without trochanters, convex in the plane of the distal condyles and flat in the direction at right angles to it. There is a huge trochanteric fossa extending from the head two-fifths the length to the condyles, bordered by a ridge on each side. The condyles present in the same direction as the fossa posteriorly. They are separated by a deep anterior and posterior emargination. Their anterior edges overhang the condylar articular surfaces, making acute angles with them. One of the articular surfaces is smaller, is anteroposteriorly extended, and has a convex ectad, and concave entad border. The other surface is also anteroposterior, reaching further distad, but not so far proximad as the other. Its area is greater than that of the other, and it is deeply notched by the entering surface of the bone ectad and proximad. It is then contracted into a wide isthmus, and the lateral grooves which produce this isthmus are overhung by the expansion of the anterior face. The anterior face of the femur is without ridges or processes.

The condition of the specimen is such that the composition of the skull may be readily made out. The postfrontal bones are large, and form the superior border of the orbit. At the front of the orbit they reach the prefontal, thus excluding the frontal. The parietal bones are wider than the frontals, and are bounded laterally by the postfrontals and the squamosals and by an element between the squamosal and exoccipital, which occupies the position of the *intercalare* of the *Stegocephali*. Below this bone, on the inner side of the suspensorium, is the probable proötic. The squamosal, or an element which I cannot distinguish from that bone, extends to the condyle of the quadrate, concealing that bone from view from externally. The quadrate is short, and thins out rapidly upwards, being closely united with the squamosal. Its condyle is set at an angle of 45° with the axes of the skull, and consists of one flat and one convex surfaces, continuous but forming a deep angle together. Exterior to the exoccipital, and interno-inferior to the intercalare, is a small distinct element, apparently in the position of an opisthotic or external occipital.

The excavation for the auditory apparatus appears to be in the exoccipital. It is almost entirely filled by what I suppose to be a large stapes. This bone is in shape like a compressed flask, with the head directed inwards and forwards, and its inferior edge produced into a prominent keel, which is produced into a point below, and free from the neck of the flask. The head is truncate, and is separated from the internal cranial wall by a narrow interspace. Its external extremity is not absolutely perfect in the specimen, but does not appear to have extended in an ossified condition be-

yond the exoccipital bone. In a specimen of *Empedias molaris** there is a meatus auditorius, in which the stapes was not found on cleaning out. This element is coösified with the surrounding bones laterally and posteriorly. Consequently when broken open, the vestibule is represented by two deep grooves, directed inwards and anteriorly.

The single species of this genus is one of the largest saurians yet obtained from the Permian of North America.

Char. specif. The superior surface of the skull is everywhere flat, as is the external face of the maxillary. The surface of the latter is marked by moderately coarse fossæ and grooves, separated by more or less fine irregular but generally longitudinal ridges. The minute sculpture of the superior cranial surface, is finer and more punctate in character. The areæ of this surface, already mentioned, are arranged as follows: There is a series over the orbits, which are separated from each other by straight grooves, and which grow larger and more swollen posteriorly. Between these supraorbital rows, the areæ of the top of the skull are separated by longitudinal grooves, except immediately between the widths of the orbits, where there are some narrow transverse areæ. On the supraoccipital region there is a median subtriangular area, and three narrow longitudinal ones on each side of it. External to these, and on the posterior part of the squamosal region, the areæ are larger and more swollen. A cluster of three of these lies between the exoccipital bone, and the smooth descending surface of the posterior edge of the squamosal. Of these the one bounding the exoccipital bone, is a robust cone, forming a short horn, like that occupying a similar place in the horned toad, *Phrynosoma douglassi*. Between the temporal areæ, and in front of the supraoccipital areæ, on each side of the middle line, there are three longitudinal areæ, which are successively narrower externally, the exterior being very narrow. On the frontal region anterior to the transverse areæ, are two wide longitudinal areæ. Each nasal bone has a small median area, from which radiate grooves, of which some of the posterior are close together.

The occiput is excavated into a large fossa on each side of a large triangular supraoccipital region. The fossæ are bounded externally by a strong exoccipital crest and at the anteroinferior corner by the "opisthotic." This bone projects posteriorly and downwards, in the form of a robust hook. The foramen magnum is not excavated so abruptly above the exoccipital facets as in *Empedias molaris*.

Measurements of Skull and Femur.	M.
Interorbital width	.108
Length from supraoccipital crest to frontonasal suture	.135
Width between apices of tuberosities of the intercalaria	.113
Length from apex of tuberosities to inferior extremity of quadrate	.129

* Figured in the Proceed. Amer. Philos. Soc. xix. p. 56.

Measurements of Skull and Femur.		M.
Diameters of quadrate condyle	anteroposterior	.020
	transverse	.039
Length of maxillary on alveolar edge		.087
Diameters base of a posterior tooth	anteroposterior	.007
	transverse	.010
" of base of another posterior tooth	anteroposterior	.005
	transverse	.010
Length of femur		.236
Proximal diameters of femur	anteroposterior	.047
	transverse	.085
Width of shaft		.052
" distally (greatest)		.115

EMPEDIAS FISSUS, sp. nov.

The species of *Empedias* form a series which diverges from *Diadectes* in a successive widening of the crowns of the teeth and diminution in their number. Thus the *D. phaseolinus* is nearest to *Diadectes; D. molaris* succeeds it, and in *E. fissus* we have the molariform character most strongly developed. In the *E. latibuccatus*, on the other hand, the diminution of the transverse extent of many of the teeth and the areolar sculpture of the superior surface of the cranium points in the direction of the genus *Chilonyx*. The species of *Empedias* may be easily distinguished as follows:

I. Surface of skull divided by grooves into areæ.

Superior teeth, 16 on each side, a number on each end of the maxillary bone of little transverse extent.....*E. latibuccatus.*

II. Surface of skull uniformly rugose.

Superior teeth narrower, 16 on each side, the last one small, sphenoid flat, pterygoids narrow.....*E. phaseolinus.*

Superior teeth wider, 14 on each side, the last one smaller, sphenoid keeled medially, pterygoids wide.....*E. molaris.*

Superior teeth wider, 14 on each side, the last the largest, sphenoid not keeled.....*E. fissus.*

Of the *E. latibuccatus* I have two specimens with teeth, one including a large part of the cranium and lower jaw. Of the *E. phaseolinus* I have five specimens with teeth, one of which embraces a nearly complete skull and a large part of the skeleton. Of the *E. molaris* I have also five individuals, of which three are crania. The *E. fissus* is represented by two individuals. One of these is one side of the entire upper jaw; the other is a broken skull with the four series of molar teeth. Of other parts of the skeleton, not identified as to species, I have a large number.

The *Empedias fissus* is nearest the *E. molaris*, and has the same number of teeth. It differs, however, in various essential points. The last maxillary tooth, which is much reduced in size in the *E. molaris*, is here as large as any of the others. The portion of the crown within the medium cusp is fissured medially in the direction of its length; that is, transversely

to the axis of the jaws. This fissure is not so distinct in the mandibular teeth. The median cusp has a straight edge at right angles to the long axis of the crown. The specimen where the entire dental series of one side is preserved, shows that the latter has a sigmoid flexure, the middle of the maxillary bone being incurved, and the anterior part convex outwards. There are five or six conic teeth between the incisors and the molars.

The inferior surface of the sphenoid bone is medially flat in transverse section, and concave anteroposteriorly, in this resembling *E. phaseolinus* rather than *E. molaris*. The upper jaw specimen shows that the muzzle projects beyond the incisor teeth, which is not the case in *E. phaseolinus*, which has the incisors very prominent. The supraorbital border is regularly convex, and not depressed and notched as in *E. phaseolinus* and *E. latibuccatus*. The superior surface of the skull is marked with innumerable small impressed pits, and assumes a spongy appearance above the orbits.

Measurements.

	No. 1.	M.
Length of last six superior molars		.055
Diameters of antepenult molar	anteroposterior	.010
	transverse	.020
Diameters of crown of incisor	vertical	.013
	transverse (at base)	.007
	anteroposterior	.011
	No. 2.	
Length of dental series in a straight line		.093
Width of palate at anterior expanse		.062
" " contraction		.068
" " between widest molars		.036

Discovered by Mr. W. F. Cummins.

EMPEDIAS PHASEOLINUS Cope, Proceeds. American Philosoph. Society, May, 1880 (*Diadectes*).

The fine specimen of this species above mentioned, which was obtained by Mr. Cummins, includes some parts of the skeleton not or rarely found hitherto. The pelvis shows that the corresponding part described by me, Proceedings of the American Philosophical Society, 1882, p. 448, belongs to another species of this group. The clavicles are preserved, and enable me to identify the corresponding part of another species in which the structure is more distinctly visible. This shows an episternum wedged in between the adjacent extremities of the clavicles, which are here very robust. But a small part of it appears in the inferior surface, but superiorly it forms a plate which covers the symphysis of the clavicles, but does not extend posterior to them. The suture of the episternum with the clavicles below is a coarse interdigitation. Posterior to it is the symphysis of the clavicles.

The skull of this specimen is the first that I have seen in this group which possesses a basioccipital bone and condyle. This proves that in the five other crania of allied species, it has fallen out, which indicates its very

weak attachment to the sphenoid. The lateral superior articular facets of the exoccipital bone are characteristic of the family, and of the genus *Chilonyx*. This skull also shows that the premaxillary bones may be distinct, and that they extend but a short distance on the superior face of the muzzle.

In this species the interorbital region is wide and concave, and the parietal regions are swollen and convex. The supraorbital border is nearly straight, and has an open notch medially.

The hyposphen varies in size in different parts of the vertebral column, and is generally very large. The neural spines have bilobate extremities.

Stated Meeting, Jan. 5, 1883.

Present, 8 members.

President, Mr. FRALEY, in the Chair.

The resignations of A. E. Outerbridge, Jr., dated May 15, 1882; of B. B. Comegys, dated Nov. 1 1882; of Alfred Stillé, dated Dec. 28, 1883; and of Horatio C. Wood, dated Jan. 3, 1883, were announced by the Treasurer, and on motion accepted.

The death of John Forsyth Meigs, M.D., at Philadelphia, Dec. 17, 1882, aged 65, was announced.

The death of the Rev'd Charles P. Krauth, D.D., Vice-Provost of the University, at Philadelphia, Jan. 2, 1883, aged 59, was announced. The President was authorized to provide for obituary notices of the deceased.

Donations for the Library were reported from the Geographical Societies at Munich, Bordeaux and Paris; the Meteorological and Astronomical Societies in London; the Society at Riga; the American Society at Paris; the Peabody Fund and the Museum of Comparative Zoölogy at Cambridge; the Boston Zoological and Natural History Societies; American Journal of Science; American Academy of Medicine; N. Y. Academy of Science; Franklin Institute;

Academy of Natural Sciences; Second Geological Survey of Pennsylvania; Union League; Library Co.; Mrs. Tyndale; U. S. Bureaus of Ethnology and Education; Washington Philosophical Society; U. S. Coast Survey; U. S. Naval Institute; Royal Asiatic Society of Shanghai; M. Leon Fernandez and the Revista Euskara.

Prof. Cope communicated a paper entitled: "First addition to the Fauna of the Puerco Eocene."

Pending nominations Nos. 969 to 980 were read.

Annual appropriations for 1883 were passed.

The request of Dr. Frazer to withdraw his Summary of the Geology of Egypt was granted.

The result of the *Annual Election* was reported:—

President.

Frederick Fraley.

Vice-Presidents.

Eli K. Price, E. O. Kendall, J. L. LeConte.

Secretaries.

P. E. Chase, G. F. Barker, D. G. Brinton, J. P. Lesley.

Counsellors for three years.

R. E. Rogers, O. Seidensticker, R. Wood, P. H. Law.

Counsellor for two years (in the place of B. F. Marsh deceased), C. A. Ashburner.

Curators.

C. M. Cresson, Henry Phillips, Jr., Geo. H. Horn.

Treasurer.

J. Sergeant Price.

The meeting was then adjourned.

Stated Meeting, Jan. 19, 1883.

Present, 8 members.

Vice-President, Mr. PRICE, in the Chair.

Dr. Pepper by letter, Jan. 8, accepted his appointment to prepare an obituary notice of Dr. J. F. Meigs.

Dr. Muhlenberg, by letter of same date, accepted his appointment to prepare an obituary notice of the Rev. Dr. Krauth.

A photograph of Admiral J. Downes, for the Album, was received.

Donations for the Library were reported from the Royal Academy, Brussels; Flora Batava; Annales des Mines; Commercial Geographical Society, Bordeaux; Royal Geological Society and London Nature; Canadian Institute; Essex Institute; Museum of Comparative Zoölogy and Peabody Museum; American Journal of Medical Science; American Journal of Pharmacy; Mr. Henry Phillips, Jr.; Ohio Mechanical Institute; T. L. Campbell; and the American Antiquarian Society.

The death of Dr. W. H. Allen, President of Girard College, August 29, 1882, aged 74, was ordered to be inserted in the minutes.

Prof. P. E. Chase communicated "Photodynamic Notes, No. VII."

Mr. Lesley communicated a Memorandum of the Progress of the Second Geological Survey of Pennsylvania, from the beginning, by Counties alphabetically arranged.

Prof. Barker exhibited and explained his new Standard Cell for testing potentials of electricity.

Dr. Frazer exhibited and described a collection of rock specimens from St. Davids and elsewhere in Great Britain, with special regard to their likeness to certain rocks in Pennsylvania.

General Thayer described some curious effects observed by him in using a secondary electrical battery.

Mr. Lesley was elected Librarian for the ensuing year.

Standing Committees were appointed, as follows:

Finance.	*Hall.*
Eli K. Price,	J. Sergeant Price,
Henry Winsor,	W. A. Ingham,
J. Price Wetherill.	C. G. Ames.
Publication.	*Library.*
J. L. LeConte,	E. K. Price,
D. G. Brinton,	E. J. Houston,
C. M. Cresson,	Henry Phillips, Jr.,
G. H. Horn,	W. V. McKean,
Persifor Frazer.	Thos. H. Dudley.

The reading of the list of members was postponed.

Pending nominations Nos. 969 to 980 were read; 979 was postponed; the rest were balloted for.

The Library Committee were instructed to proceed with the printing of the last part of the Catalogue. (530 MSS. pages = 270 ± pp. of text.)

A Committee of three was appointed to draw up a *Memorial to Congress* urging the continuance of the Light House Board and the Coast Survey under the direction and control of the U. S. Treasury Department, the Committee to consist of Messrs. Fraley, Dudley and Frazer.

New members elected:—

J. Bennett Lawes, LL.D., of Rothumstead, Herts, Eng.
J. O. Westwood, Hope Prof. Entom., Oxford, Eng.
J. Cheston Morris, M.D., of Philadelphia.
Jas. Russell Lowell, Min. Plen. U. S. to England.
Herbert Spencer, of England.
Rev. Joseph May, of Philadelphia.
Wm. Morris Davis, of Philadelphia.
S. F. Emmons, U. S. Geologist, Washington, D. C.

James Macfarlane, of Towanda, Penna.
E. W. Claypole, 2d Geol. Survey, New Bloomfield, Perry Co., Pa.
Wm. H. Pancoast, M.D., of Philadelphia.
And the meeting was adjourned.

Stated Meeting, Feb. 2, 1883.

Present, 14 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Rev. Jos. May, Jan. 23, and Mr. W. M. Davis, Milestown (Phil.), Jan. 23.

Letters of envoy and acknowledgment were read.

Donations for the Library were reported from the Mining Department, Melbourne; Geographical Soc., St. Petersburg; Turin Observatory; Academia dei Lincei; Revue Politique; Commercial Geographical Society, Bordeaux; Royal Museum of Natural History, Brussels; Royal Astronomical Society and Kew Observatory, London; Nova Scotia Institute; Massachusetts Historical Society; Museum of Comparative Zoölogy; Amer. Jour. of Science; Meteorological Observatory, Central Park, New York; New Jersey Historical Society; Franklin Institute; H. Phillips, Jr.; McCalla & Stavely; Amateur Naturalist (Germantown); American Chemical Journal; American Journal of Mathematics; Signal Service Bureau; U. S. National Observatory; Engineer Department U. S. A.

Proceedings A. P. S. No. 112, was laid on the table.

Dr. W. H. Pancoast was appointed to prepare an obituary notice of Prof. Joseph Pancoast.

Dr. Rothrock read a memoir on the microscopic differences in woods. (See page 599.)

After a discussion of the subject by Messrs. Price, Davis,

Rothrock, Lesley, Frazer and Kane, with special reference to the occurrence of abnormal rings in timber, Mr. Price desired it to be remarked that Dr. Rothrock's important practical discovery was the direct result of the practical use to which the American Philosophical Society had put its portion of the Michaux Legacy, as the minutes of the last few years show.

Dr. Frazer communicated a paper entitled: "Some Comparative tables showing the distribution of Ferns in the United States," by Geo. E. Davenport, of Medford, Mass. (See page 605.)

Dr. Frazer presented the report of the Special Committee on a Memorial to Congress, which was approved, and the Officers were authorized to sign the Memorial and transmit it to Congress. The Committee was discharged from the consideration of that part of the subject which related to the Light House Board.

The President reported that he had received and paid over to the Treasurer $132.75, being the quarterly interest on the Michaux Legacy last due.

On motion of Mr. Price, the expense of preparing the illustrations of Dr. Rothrock's paper was charged to the Michaux Legacy fund.

Stated Meeting, Feb. 16, 1883.

Present, 11 members.

President, Mr. FRALEY, in the Chair.

Messrs. Macfarlane, Claypole and Emmons by letter accepted their election to membership.

Letters of acknowledgment and envoy were read.

Donations for the Library were reported from the S. N. Antiq., Copenhagen; Royal Academia dei Lincei; Geographical Societies at Paris and Bordeaux; Revista Euskara;

Kew Observatory; London Nature; Royal Geological Society, Cornwall; Boston Natural History Society; Mr. Geo. B. Dixwell; American Antiquarian Society; Wesleyan University; Regents of the University, N. Y.; Numismatic and Antiquarian Society; Engineer Club; Mr. H. Phillips, Jr.; Dr. D. G. Brinton; American Journal of Pharmacy; Second Geological Survey of Pa.; U. S. Mint; War Department; Wisconsin Historical Society; and Mrs. R. Norris of Nice in France.—A rare copy of Kaempfer's Japan; and a MS. volume of Japanese flowers, painted by native artists for Mr. Geo. Tyson of Boston during his residence in China, were presented by Mr. Morris Davis of Milestown, Phila.——Capn. A. D. Bache, presented, through Mr. Fairman Rogers, an old MS. of the Address of the Earl of Macclesfield to the Royal Society at the presentation of the Coplay Medal of 1753 to Benjamin Franklin. This MS. has the appearance of being the original document. On motion the thanks of the Society were tendered to Mr. Bache.

The death of Dr. B. H. Rand, at Philadelphia, February 14, aged 55, was announced.

Mr. Lewis introduced a discussion upon the thickness and movement of the Continental Glacier, in which Messrs. Frazer, Lesley and Price took part.

The minutes of the last meeting of the Board of Officers were read.

Pending nominations Nos. 979, 981 and new nominations Nos. 982, 983 and 984 were read.

Resolved, That the President be authorized to appoint as delegates to the Congrés des Americanistes, to meet at Copenhagen next September, any members of the Society who expect to be present on that occasion, provided that the Society be not subjected to any expense by the delegation.

Dr. Brinton and Mr. Henry Phillips, Jr., were appointed.

Resolved, That the Finance Committee be requested to investigate the condition of the Magellanic Premium funds, and make recommendations for the appropriation of the surplus income fund for such purpose or purposes as they may think appropriate to the objects of the Society.

And the meeting was adjourned.

Stated Meeting, March 2, 1883.

Present, 14 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from J. O. Westwood, of Oxford, England, dated February 12; and from James Russell Lowell, dated London, Feb. 11.

Letters of acknowledgment and envoy were read.

Donations for the Library were received from the Geographical Societies of Paris and Bordeaux; Revue Politique; Belgian Academy; Abbé Renard; E. Ludwig; Royal Society, Society of Antiquaries and London Nature; Dr. Ed. Jarvis; U. S. Military Academy; Prof. Mansfield Merriman; Dr. C. H. F. Peters; New Jersey Historical Society; Mr. T. H. Dudley; Franklin Institute; Mr. E. S. Holden; U. S. Naval Institute; San Francisco Mercantile Library Association; American Journal of Science; "Science"; U. S. National Museum; Census Bureau; C. A. Ashburner, and B. S. Lyman.

Mr. Horatio Hale read a paper on the Tutelo Indians and their language. (See Vol. XXI, page 1.)

Dr. Frazer exhibited two aneroid barometers and described some useful improvements suggested by him, executed by Hicks of London. (See page 604.)

Pending nominations Nos. 979, 981 and 984 were read.

Prof. Cope described as preposterous certain current newspaper explanations of the cause of the extinction of fossil mammalia in the West, by cold and by drought.

And the meeting was adjourned.

PROC. AMER. PHILOS. SOC. XX. 113. 4C. PRINTED MAY 2, 1883.

Stated Meeting, March 16, 1883.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

Letters of envoy and acknowledgment were read.

Donations for the Library were reported from the Societies at Moscow, Königsberg, St. Gall, Frankfurt, Wiesbaden, Bordeaux and Cherbourg; the Observatories at St. Petersburg, Cambridge, Mass., and Mt. Hamilton; the German Geological Society, Physical Society, and W. Franzen of Berlin; the Belgian Academy, Bureau of Statistics, and Bureau of the Interior; the Lyons Society of Agriculture and Musée Guimet; the Flora Batava; the Society of Geography, Antiquaries, Anthropology, and Geology of Paris; the Revue de l'Histoire des Religions and Revue Politique; the Royal Institute, Victoria Institute, Met. C. R. Society; Royal Geographical, Royal Asiatic, Geological and Zoological Societies; London Nature; Boston National History Society; "Science"; N. Y. Linnean Society; Index Medicus; American Journal of Pharmacy; H. C. Lewis; Public Building Commission, Phil.; U. S. Coast Survey, Bureau of Education, Interior Department, National Museum; Missouri Historical Society; Hamilton A. Hill, of Boston; P. P. Sharples (Copy of the Monthly Mag. for Jan. 1784); and Mr. Henry Phillips, Jr.

An Obituary notice of Dr. Krauth, was read by Dr. Muhlenberg. (See page 613.)

The death of the oldest member of the Society, Mr. Henry Seybert, at Philadelphia, March 3, aged 82, was announced by Mr. J. S. Price; and the President was requested to select a suitable person to prepare an obituary notice of the deceased.

Dr. Brinton read a paper entitled "On Mediæval Sermon Books and Stories," by Prof. T. F. Crane, of Cornell University. (See Vol. XXI, No. 114.)

Prof. Cope communicated a paper entitled "Fourth Contribution to the History of the Permian Formation of Texas." (See page 628.)

The action of the Curators was approved in regard to lending for scientific examination the Mexican flutes belonging to the Cabinet of the Society, deposited at the Academy of Natural Sciences.

Dr. Frazer took occasion from Dr. Brinton's remarks prefatory to the reading of Prof. Crane's paper, to express his views regarding the presumptive restriction of authors of papers from using already published matter in said papers. Mr. E. K. Price and Mr. Fraley explained the habitually liberal policy of the Society in respect of communications made for publication. Mr. Lesley expressed the hope that the broadly "philosophical" character of the Society would be maintained, and that the Proceedings would not become restricted to the narrow limits of Natural History or the Physical sciences, so called, but that the Society would encourage its members to communicate for publication their best mature thinking in whatever department of human knowledge they might engage.

Pending nominations Nos. 979, 981 to 984 were read, and the meeting was adjourned.

Stated Meeting, April 6, 1883.

Present, 13 members.

President, Mr. FRALEY, in the Chair.

Memberships accepted: G. Planté; J. B. Lawes.

Membership declined: Jos. May.

Letters of acknowledgment were received from the Royal Society of New South Wales (107–111); M. Edw. Dupont (111); Geological and Natural History Survey of Canada,

Toronto (57-60, 61-62, 67, 69, 75, 87; III, IV, V); Smithsonian Institution (112); and Mr. Thos. C. Porter (112).

Letters of envoy were received from the Geological Survey of India; University at Lund; Batavian Society, Rotterdam; Oberhessischen Gesellschaft, Giessen; and the Meteorological Office, London.

A letter of envoy, requesting exchanges, was received from the Historical and Scientific Society of Manitoba, Winnipeg, March 20, 1883. [See below.]

Donations were received from the Academies at St. Petersburg, Copenhagen, Brussels, Rome, Madrid and Philadelphia; the Royal Societies, in N. S. Wales, Victoria, Rotterdam and London; the Royal Astronomical Society at London; the Royal Society of Antiquaries, Copenhagen; the Geological Society at Halle; the Geological Surveys of India, New York, and New Jersey; the Geographical Societies at Paris and Bordeaux; the Historical Societies in Providence, Wilkesbarre and Winnipeg, Manitoba; the Swedish Bureau of Statistics; Lund University; Upper Hessian Society; General Society of Prisons at Paris; Observatory at San Fernando; the Revista Euskara; London Nature and National Review; Boston Society of Natural History; S. H. Scudder; H. A. Hill; Silliman's Journal; Franklin Institute, American Journal of Pharmacy, American Journal of Medical Sciences, T. Dudley, H. Phillips, Jr., H. C. Lewis, Dr. J. G. Lee, P. P. Sharples, of Philadelphia; American Chemical Journal; F. B. Hough, of Washington; Ohio Mechanics' Institute; National Mexican Museum.

A letter from Mr. Moncure Robinson was received accepting his appointment to prepare an obituary notice of Henry Seybert.

The death of Daniel B. Smith, at Germantown, March 29th, in the 92d year of his age, was announced by Mr. Fraley; and Prof. P. E. Chase was appointed to prepare an obituary notice of the deceased.

Mr. Davis read a paper "On the conversion of chlorine

into hydrochloric acid, as observed in the deposition of gold from its solution by charcoal."

Prof. E. W. Claypole communicated, through the Secretary, two papers entitled, "On the Kingsmill white sandstone," and "Note on a large fish-plate from the Upper Chemung (?) beds of Northern Pennsylvania."

Rev. J. Hagen, S. J., Prof. College of the Sacred Heart, Prairie du Chien, Wis., communicated, through Dr. Brinton, a paper entitled, "On the reversion of series and its application to the solution of numerical equations."

Mr. John Sharples communicated through Prof. P. E. Chase, a paper entitled, "The latitude of Haverford College."

Mr. Lockington read a paper entitled, "The role of parasitic protophytes; are they the primary or the secondary cause of zymotic diseases."

Dr. Barker exhibited two bronze medals which he had received, in Paris, as a delegate to the International Congress of Electricians, and as a Commissioner to the International Exhibition of Electricity, held in Paris in 1881; and also a medal struck by the Institut de France in commemoration of the transit of Venus.

Pending nominations Nos. 979, 981–984, and new nomination No. 985, were read.

The Historical and Scientific Society of Manitoba, Winnipeg (see its letter, March 20), was ordered to be placed on the list of corresponding Societies to receive the Proceedings from date.

Dr. Brinton in behalf of the owners offered some valuable documents. On motion, the President was requested to examine them and report to the Society.

The Finance Committee reported "that in the matter of the Magellanic Fund referred to it, the subject was considered, assisted by the President, and it was concluded that no change in the present regulations was needed." Report accepted.

The Secretaries were authorized to publish with Mr. Hale's paper on the Tutelo Indians a fac-simile photograph of the old Tutelo Chief, the last of his tribe. (See No. 114.)

The Committee on the Michaux Legacy reported as follows:

"That the appropriation made for a course of lectures in Fairmount Park for 1882 by Professor Rothrock, to wit, two hundred and eighty dollars for the Professor, and fifty dollars for advertising, was duly received from the Treasurer, and applied as intended.

"The lectures, fourteen in number, were upon the subjects in the annexed printed schedule; and were attended by increased numbers of citizens of both sexes. There is a growing interest in these subjects in our community, amply to justify the Society's appropriation in that direction. The Committee recommend the same amounts to be voted for 1883, for lectures as in Schedule No. 2, annexed."

It was then, on recommendation of the Committee,

Resolved, That an appropriation be made from the Michaux Legacy of two hundred and eighty dollars for Professor Rothrock's lectures in Fairmount Park, and fifty dollars for advertising them, and that the Treasurer be authorized to make payments under the direction of the Chairman of the Committee on the Michaux Legacy.

The following schedule of proposed lectures for 1883 was appended to the report:

Free Lectures in Fairmount Park, on Botany and Tree Culture, by Professor Rothrock, on Saturdays, at 4 P. M.

April 21. The value of Science to Mankind.
" 28. Young Plants; how studied in life.
May 5. Relations of Plants to National Prosperity.
" 12. The Microscope; what it is; what it does; how to use it.
" 19. A thriving colony on a Spruce Tree.
" 26. What the Leaves do, and how they do it.
June 2. Wasted food.
Sept. 8. The Forests of the Sea.
" 15. The American Forests, and their special importance.
" 22. American Timber, and its special value.
" 29. Old and new systems of Classification.
Oct. 6. Vegetable Units, and how they make the plant.

The Curators reported the safe return of the Mexican flutes borrowed by Mr. Cresson, and studied by Mr. Cox,

who had obtained from them a diatonic scale of an octave and a quarter in extent.

The Librarian reported the completion of his MS. condensed copy of the early records of the Proceedings of the Society from 1744 to 1837. The subject of printing the same was referred to the Committee of Five (Phillips, Horn, Lewis, Brinton and Law) appointed December 16, 1881.

And the meeting was adjourned.

On the Measurement of Electromotive Force. By George F. Barker.

(*Read before the American Philosophical Society, January 19, 1883.*)

The term electromotive force is applied to that force which tends to set electricity in motion. It appears to have been used first by Ohm, who in 1827 gave precision to the study of electric currents by formulating his well known law:—The strength of an electric current is directly proportional to the sum of the electromotive forces and inversely proportional to the sum of the resistances in the circuit.

The measurement of electromotive force may be absolute or relative; absolute when it is determined directly, relative when its value is obtained by comparison, the ratio of an unknown to a known electromotive force being the object of the measurement. In both measurements, the final standard of electromotive force is an absolute unit, based upon the fundamental units of mass, length and time; since these are respectively the centimeter, the gram and the second, absolute units are often called C. G. S. units. In electrostatics, electromotive force and difference of potential are synonymous, the same unit being used for both. The unit difference of potential exists between two points, when to carry a unit of positive electricity from one to the other, requires the expenditure of a unit of work; or in the C. G. S. system, of an erg. Now a unit of work, *i. e.*, an erg, is done when a unit of force, *i. e.*, a dyne, overcomes resistance through an unit of distance, *i. e.*, a centimeter. And a unit of force, *i. e.*, a dyne, is that force which produces a unit of velocity in a unit of time; *i. e.*, produces an increase of velocity of one centimeter in one second. Since in this latitude, gravity produces a velocity of about 980 centimeters per second, the force of a dyne corresponds to the attractive force which the earth exerts upon the 1-980th part of a gram. To raise one gram therefore to the height of one centimeter requires the expenditure of 980 ergs of work. Obviously then if two electrified bodies at unit distance attract or repel each other with a force equivalent to that which

the earth exerts on a gram weight, there exists between them a difference of potential of 980 absolute units. By measuring the force between two electrified bodies in grams, the difference of potential or the electromotive force between them is easily calculated in absolute measure. By multiplying this value in electrostatic units, by thirty thousand million, the electromotive force is obtained in absolute electromagnetic units.

The instrument used for measuring differences of potential is called an electrometer; if by direct measurement, an absolute electrometer. The absolute electrometer of Sir William Thomson is the best thus far devised. This instrument consists of two metal plates, one of which, the smaller, is provided with a guard ring so that the electrical distribution shall be uniform; these plates being so arranged that the attraction between them may be very accurately measured. The force may be measured at a constant distance by varying the weight necessary to balance it; or the distance may be varied until the force balances a constant weight. The latter method is preferred in the absolute electrometer of Thomson. With this instrument, the electromotive force of a Daniell cell was found to be 0.00374 electrostatic unit, corresponding to 112 million electromagnetic units.

Relative measurement of electromotive force, especially for practical purposes, is much more frequent than absolute measurement. Although the same units may be used, yet in practice it has been found more convenient to employ a separate unit called the volt, the value of which is given as one hundred million absolute electromagnetic units. Moreover, this unit is represented not in the abstract form alone, but also concrete. Some distinct electromotor, the difference of potential between the electrodes of which has been accurately measured, is taken as the standard. For example, the Daniell cell above mentioned has an electromotive force, by the definitions already given, of 1.12 volts. Such a battery, used for measurement, is called a standard battery.

For determining an unknown electromotive force, it is only necessary to determine the ratio between this and the electromotive force of the standard battery. Two general methods of doing this are in use; the one direct, the other indirect. In the direct method, an electrometer which has been calibrated is employed; *i. e.*, one whose constants have been determined by comparison either with the standard battery or with an absolute instrument. Such are the portable and the quadrant electrometers of Thomson. In the latter instrument an 8-shaped needle of aluminum swings in a cylindrical metal box with separated quadrants. The alternate quadrants are electrically connected when the instrument is in use. A small charge being communicated to the needle—previously adjusted so that its axis is parallel to the line between adjacent quadrants—any electrification of the quadrants is made apparent by the motion of the needle to the right or left. By connecting these quadrants, first with the electrodes of the standard cell, and then with the cell whose electromotive force is to be measured, the ratio of the deflections gives the ratio of the electromo-

tive forces, provided the angle of rotation be small. A mirror attached to the suspension of the needle enables these deflections to be accurately read with a telescope and scale. A simpler instrument suffices when the zero method is employed. In this case the two electromotors are simultaneously connected to the quadrants, their electrodes being reversed. If equal, the deflection will be zero. If unequal, it will be equal to the difference. By varying the known electromotive force until the deflection is zero, the two are again equal.

While, in the direct method, the electromotive force is the quantity which is measured, in the indirect method some other quantity or quantities are measured, and the electromotive force deduced by calculation from the known relation between the quantities. When, for example, the current strength is measured on the galvanometer and the resistance of the circuit is known, the law of Ohm enables the electromotive force to be computed. In Wiedemann's method, the electromotor to be measured is joined up with the standard battery, in circuit with a galvanometer, first with the electrodes in the same direction, then reversed. The electromotive force required is then the product of the standard electromotive force by the quotient of the difference of the current strengths divided by the sum. Another method consists in putting the standard cell in circuit with a galvanometer, the resistances of both being known. The standard cell is then replaced by the electromotor to be tested and the resistance in circuit varied until the same deflection is obtained. The electromotive force of the standard cell multiplied by the ratio of the second total resistance to the first gives the electromotive force required. The electrometer methods have the advantage of not using the current of the electromotor to be measured; and hence any change in its condition due to the current produced is avoided.

From what has been said, it will be evident that the selection of the standard cell is a matter of prime importance. The advantages of the Daniell cell for this purpose are too well known to require elaborate statement here. As used on closed telegraphic circuits and the like, two forms have come into general favor. One of these is that employed originally by Professor Daniell. It consists of a glass jar containing copper sulphate, in which the copper plate is immersed, and of a porous cup containing the zinc plate, a more or less dilute solution of zinc sulphate. The other form is the modification first proposed by Varley and afterward by Callaud, in which the porous cup is done away with, the differing densities of the two solutions being depended upon to keep them separated. The copper sulphate solution is placed at the bottom of the jar in contact with the copper plate. As the density of this solution when saturated is 1.186 at 15° C. the solution of zinc sulphate ordinarily rests upon it and in contact with the suspended zinc plate. But as the action of the battery goes on and the zinc sulphate accumulates in the solution, this later finally becomes heavier than the copper sulphate solution (the density of a saturated solution of zinc sulphate being 1.44 at 15° C.), and

falls to the bottom ; thus reversing the normal conditions in the battery. In 1871 Sir Wm. Thomson attempted to reverse the position of the plates in this gravity battery and place the zinc at the bottom in contact with the heavier solution. But the collateral disadvantages arising from the change more than balanced the advantages. He returned to the old form, therefore, but arranged a siphon in such a way that the zinc sulphate solution should be gradually withdrawn and too great concentration avoided. In practice the zinc sulphate should never be allowed to accumulate so as to increase the density of the solution above 1.17. This may be accomplished readily by pouring off the solution from the top of the jar and replacing it by pure water. When freshly set up, both of the forms of battery above described require to be kept on closed circuit for a day or two. Their condition of equilibrium is then reached and they may be used for the determination of electromotive force.

The difference of potential between the electrodes of a Daniell cell has been determined by many experimenters; by Regnauld, by Poggendorff, by Buff, by Beetz, by Petruschefsky, by Clark and Sabine, and by Ayrton and Perry, among others. They find that while it varies somewhat under variations of condition, yet that on the whole, it is remarkably constant, the maximum being 1.081 and the minimum 0.901 volt. In all these experiments the copper was immersed in a saturated solution of copper sulphate. The zinc was placed in solution of sodium chloride, in dilute sulphuric acid or in solution of zinc sulphate, all of varying strengths in the different experiments. It is noticeable that in none of these measurements made by indirect methods is the electromotive force as high as that already mentioned as having been obtained by Sir William Thomson by means of his absolute electrometer. Since the electromotive force of a Daniell cell is the sum of the differences of contact-potential within it, it would seem that any variation in the value of this electromotive force must be due either to a change in the character or concentration of the solutions, or to a difference of temperature. Moreover it has been observed that the electromotive force of the gravity form of battery is always a little higher than that of the cell in which a porous cup is used ; a result due, probably, to the different conditions under which the diffusion of the two liquids takes place, a fact pointed out by J. W. Draper in 1834.

Using, therefore, the same form of battery, the solutions being always the same in kind and in concentration, and the temperature being the same, it is fair to infer that the Daniell cell may be made sufficiently constant to serve as a reliable standard of electromotive force. Several attempts have been made to do this. Raoult in 1864 (*Ann. Chim. Phys.*, IV, ii, 345), proposed a standard cell consisting of two covered jars of glass, one containing a copper plate in a saturated solution of copper sulphate, the other a zinc plate in a solution of zinc sulphate in an equal weight of water. The two were connected by an inverted U tube, whose ends were closed by porous plates of earthenware cemented to them. By

means of a tubulure in the bend this tube was filled with the zinc sulphate solution. When not in use, the U tube is removed and kept in a separate vessel. Kempe in 1880 (*J. Soc. Teleg. Eng.*, June, 1880), described a standard Daniell cell which has been adopted in the British Post-Office. The containing vessel is of porcelain, having two compartments. In one of these is a half saturated solution of zinc sulphate, reaching to the lower edge of the zinc plate. In the other is a flat, porous cup containing the copper plate surrounded with crystals of copper sulphate, and immersed in copper sulphate solution. To use this battery, the porous cup is transferred from one compartment to the other, thus raising the zinc solution into contact with the zinc plate. After making the measurement, the porous cup is replaced in its own compartment. Any copper which may have been carried into the zinc solution is precipitated upon a fragment of zinc kept constantly in it.

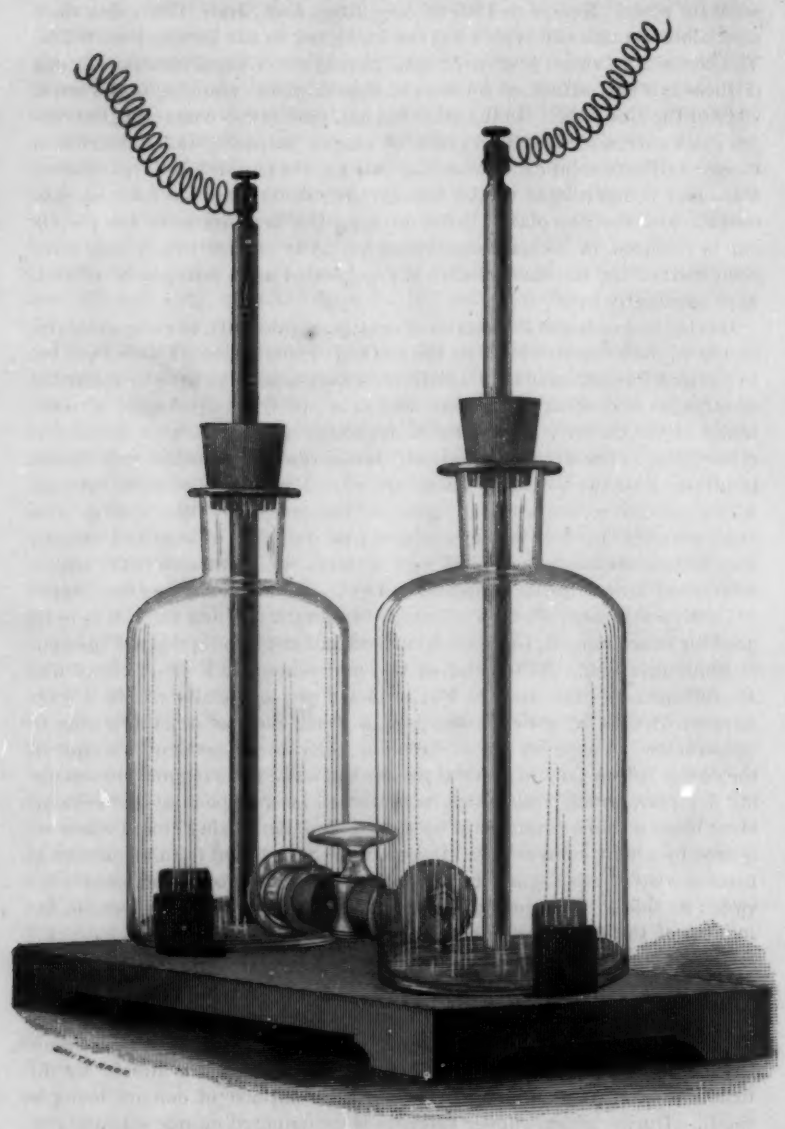
Having had occasion for a series of months, at intervals, to make measurements of electromotive force by the method of comparison, I have been led to devise a form of standard Daniell cell which appears to have so important advantages over others heretofore used as to justify me in bringing it to the notice of the Society. The form of apparatus which has been adopted is represented in the annexed wood-cut. It consists of two bottles with lateral tubulures near the bottom. These are closed with rubber corks through which passes a stop-cock of glass. The necks of the bottles also carry corks of rubber, through which pass the rods of zinc and copper. The bottle containing the rod of zinc is filled about three-fourths with a solution of zinc sulphate saturated at 15° C. That containing the copper rod with a saturated solution of copper sulphate. When the cell is to be used for measurement, the cock is opened and the two liquids are thus put in communication. At the end of the experiment, it is again closed and all diffusion is prevented.* For ordinary use, especially where a large number of cells in series is required, a much cheaper apparatus may be constructed. Those set up in my own laboratory consist of a couple of the cheap bottles now in general use for the nasal douche and for containing dry plate developers, which have a small lateral spout at the bottom. Over these a rubber tube may be passed and tied, being closed when required by a wire compressor. In practice I have found it an advantage to place a wisp of spun glass in the rubber tube to prevent adherence between its sides. The zinc and the copper rods pass through corks in the mouths of the bottles as before.

The advantages which are claimed for this new form of cell are :

1st. Its constancy. When set up, all such cells are identical. The zinc is in contact with a solution of zinc sulphate, and the copper with one of copper sulphate both saturated at 15° C. Moreover, this identity continues. When on closed circuit, the liquids are altered by diffusion to a scarcely appreciable extent, the surface of contact being so small. During action copper sulphate is decomposed on one side and cop-

* The cell here represented was made for me by J. W. Queen & Co., of this city.

per deposited; zinc is dissolved on the other side and zinc sulphate produced. The amount of current used in a measurement is small, first be-



cause the internal resistance of the cell is high, and second because the duration of the test is brief. But the minute change thus caused in the

solution is prevented, first, by keeping a crystal of copper sulphate in the copper solution, and second, by the deposition of the excess of zinc sulphate in crystals. Since the zinc solution is the heavier, any hydrostatic transfer will be into the copper solution where no damage is done. When the cell is on open circuit, no diffusion takes place, communication being cut off. And since the apparatus is wholly closed to the air, no change in the conditions can arise from evaporation. Provided therefore the temperature be uniform, the electromotive force of the cell may be expected to be constant within narrow limits.

2d. Its transportability. In the use of the ordinary Daniell cell, particularly of the gravity pattern, any change of position disturbs more or less the conditions of equilibrium, and so varies the electromotive force. After moving such a cell, therefore, or after altering in any way its normal state, as by adding water lost by evaporation, it is necessary to allow twenty-four hours or more of rest, before the battery can be trusted to give proper measurements. But in the cell now preposed, no change can take place in its conditions by being moved from place to place. Hence for local testing in circumstances where a permanent battery cannot be had, its value is considerable.

3d. Its convenience and cheapness. The common form of Daniell battery requires to be especially prepared for use. If set up anew, twenty-four hours are needed before it comes into good working action. Even the improved forms of standard cell above described are more or less inconvenient, since they require something to be done to put them in action. But in the form now proposed the cell is always ready for use, no matter how long a time may have elapsed since it was used before. The opening of a stop-cock puts it in full operation. Moreover, this cell is readily constructed from apparatus and material at hand in every laboratory. And if douche bottles are used, the cost is not over a dollar.

It is evident that the form of apparatus now described has a much wider range than has yet been claimed. By its means not only may the effect of using various solutions in contact with either plate of a Daniell cell be accurately studied, free from many of the disturbing causing hitherto encountered, but by the use of various metals also, the innumerable questions of importance, concerning not only primary but also secondary batteries, may be conveniently investigated. One of these for example, is the question whether the zinc of a Daniell cell should be amalgamated. The impression is very generally in favor of amalgamation, since in a zinc sulphate solution amalgamated zinc is said not to become polarized; and since the electromotive force is one or two per cent. higher. But experiments have shown, that while amalgamated zinc should be used when the solution is acid, yet that when it is neutral, local action is greater with amalgamated than with unamalgamated zinc.

Experiments now in progress with this new form of cell, it is hoped, will enable some of these doubtful points to be satisfactorily settled.

PHILADELPHIA, January 18, 1883.

Henry Draper.

(*Minute prepared by Geo. F. Barker, Secretary American Philosophical Society, for Proceedings, December 1, 1882.*)

Henry Draper was born on the 7th of March, 1837, in Prince Edward county, Va., his father being at the time Professor of Chemistry and Natural Philosophy in Hampden Sidney College. When but two years old, his father was called to the chair of Chemistry in the University of the City of New York, and removed to that city in 1839. Henry was entered as a regular scholar, first in the primary, and subsequently in the preparatory schools connected with the University, and at the age of fifteen, entered the collegiate department as an undergraduate. Upon the completion of his sophomore year, however, he abandoned the classical course and entered the medical department, from which he graduated with distinction in 1858. The following year he spent in Europe. While abroad he was elected on the medical staff of Bellevue Hospital; and on his return he assumed the position and discharged its duties for eighteen months. In 1860, at the age of 23, he was elected Professor of Physiology in the Classical department of the University, and, in 1866, to the same chair in the Medical department; being soon after appointed Dean. In 1873, he severed his connection with the medical department; and in 1882, upon the death of his father, he was elected Professor of Chemistry in the Classical department; a position which he held until the close of the current academic year.

Reared in direct contact with science and scientific thought, as Dr. Draper was, it is not surprising that at an early age he developed a decided preference for scientific pursuits. His father was a man not only of the widest scientific knowledge, but he was also of exceptional ability as an investigator. To live in contact with this genial and learned man, was of itself a scientific education of the highest type. Henry was early taken into his confidence in scientific matters, and was called upon to assist his father not only in his lectures, but also in his investigations. The scientific spirit which presses forward unflaggingly in the pursuit of truth and which wrests from Nature the profoundest secrets by patient and long continued application, had long been characteristic of the elder Draper; it was now fully developed in his son. While yet a medical student, he undertook a most difficult research upon the functions of the spleen; and, conscious of the inaccuracies incident to drawings, he illustrated this research—afterward published as his graduating thesis—with microphotographs of rare perfection for those early days, all taken by himself. While engaged with the microscope in making these photographs, he discovered that palladious chloride had a remarkable power in darkening or intensifying negatives; an observation subsequently of much value in photography.

During his sojourn in Europe, he had visited the great reflecting telescope of Lord Rosse at Parsonstown, Ireland. The sight of this instrument

inspired him with a desire to construct one like it, though on a smaller, scale, and turned his attention toward astronomy and astronomical photography. Soon after his return he began the construction of a metal speculum, fifteen inches in diameter, completing it in 1860. Subsequently he accepted a suggestion contained in a letter written to his father by Sir John Herschel, and abandoned speculum metal for silvered glass. In the year 1861, he made several mirrors of silvered glass, 15½ inches in diameter. The best of these was mounted as a Newtonian telescope, in a small wooden observatory erected at Hastings-on-Hudson, his father's country seat. The details of grinding, polishing, silvering, testing and mounting this reflector, all of which he did with his own hands, were published as a monograph by the Smithsonian Institution. This publication has had a deserved popularity, and has become the standard authority on the subject. Much experimental work was done with this telescope; that which is best known, being his photograph of the moon. More than 1500 original negatives were taken with this instrument. They were one and a quarter inches in diameter, but such was the perfection of their detail that they bore enlargement to three feet, and in one case to fifty inches without injury. The success of this mirror stimulated him to undertake a still larger one, and, in 1870, he finished a silvered glass mirror, twenty-eight inches in diameter. A new dome was built for it by the side of the old one, the mounting being equatorial, and the telescope Cassegrainian; though subsequently a plane secondary mirror was substituted for the convex one. A refracting telescope of five inches aperture was attached to the tube of the reflector, as a finder. With this larger instrument, work was at once begun upon photographic spectra; and, in 1872, a beautiful photograph was obtained of the spectrum of α Lyræ (Vega), which showed the dark lines; a step far in advance of anything which had been accomplished in this direction up to that time. Desiring to make simultaneous eye-observations, Dr. Draper, in 1875, placed upon the same axis, a refracting telescope of twelve inches aperture, made by Alvan Clark & Sons. In 1880, this was exchanged for another refractor by the same makers, of eleven and a half inches aperture, but furnished with an additional lens to serve as a photographic corrector. The work of stellar spectrum photography went steadily on, the new refractor now doing the principal work. More than a hundred such photographs were made, most of these having upon the same plate a photograph of the spectrum of Jupiter, Venus, or the moon. These latter, giving the solar lines by reflection, enabled the stellar lines to be identified by direct comparison.

Reflecting on the extreme sensitiveness of the dry-plate process in photography, he was led to experiment on the reproduction of nebulæ by its means; and on the 30th of September, 1880, he succeeded by an exposure of fifty-seven minutes in obtaining a photograph of the nebula in Orion. Satisfied now that the idea was an entirely feasible one, he devoted himself uninterruptedly to securing the greatest possible perfection in the driving clock and to improving the details of manipulation. In March, 1881, a

second and much superior photograph of this nebula was secured after an exposure of 104 minutes. And finally, a year later, on the 14th of March, 1882, he succeeded in making a successful exposure of 137 minutes, and in producing a most superb photograph, which showed stars of the 13.7 magnitude, invisible to the eye, and in which the faint outlying regions of the nebula itself were clearly and beautifully shown. 'This unrivaled photograph, by far the most brilliant success yet achieved by celestial photography, will ever have a very high astronomical value, since by a comparison with it of photographs of this nebula, taken many years subsequently, changes which are going on in it may be traced and their history written. Ordinarily the photograph of a spectrum is more difficult than one of the object itself. But in this case it is not so. The spectrum being of bright lines, the light is localized and readily impresses the plate. Moreover, any error in the rate of the clock or any tremors of the instrument, which are fatal to the nebula, count for little in photographing its spectrum; since the image is thereby simply shifted off the slit and no injury results to the definition. Many excellent photographs of the spectrum of the nebula in Orion were obtained by Dr. Draper, however, the chief interest in which consists in the fact that beside the characteristic bright lines, there are traces of continuous spectrum in various parts of the nebula, suggesting the beginning of condensation.

Beside the work done at his observatory at Hastings, which may be called astronomical work proper, Dr. Draper occupied himself with collateral questions of not less importance, in the admirably equipped physical laboratory he had built in connection with his residence in New York City. It was here, in 1873, that he made the exquisite, and to this day unequaled photograph of the diffraction spectrum. The region from wave-length 4350, below G, to wave-length 3440 near O, was contained upon a single plate. The Roman astronomer Secchi reproduced this photograph as a steel plate for his great work on the Sun, and the British Association, in 1880, endorsed it as the best known standard spectrum by publishing a lithograph of it in their Proceedings. The grating used to produce this photograph was one of Mr. Rutherfurd's superb plates, ruled with 6481 lines to the inch. It was in his New York laboratory, too, that he made the most important discovery of his life, perhaps; that of the existence of oxygen in the sun. After months of laborious and costly experiment, he succeeded, in 1876, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate, with their edges in complete contact; thus enabling the coincidence or non-coincidence of the lines in the two spectra to be established beyond a doubt. On examining the spectrum of oxygen thus photographed, he saw that while the lines of the iron and the aluminum used as electrodes, coincided, as they should do, with their proper dark lines in the sun's spectrum, the lines of oxygen agreed with bright solar lines. Whence the important conclusion announced by him, 1st, that oxygen actually existed in the sun, now for the first time proved; and, 2d, that this gas exists there under conditions either of tempera-

ture or pressure, or both, which enable it to radiate more light than the contiguous portions of the solar mass. This view of the case however, required radical modification in the then accepted view of the constitution of the sun; a modification which he pointed out and advocated. So exceptional were these results, and especially the conclusions from them, that it was hardly to be expected that they should be at once accepted. Dr. Draper, however, in this, as in all his work, was his own severest critic. Increasing constantly his appliances and perfecting his methods he produced, in 1879, another photograph on a much larger scale, which showed the coincidences which he claimed, especially of groups of lines, so unmistakably as to leave no question of the fact in a mind free from bias. To strengthen still more the evidence on the subject, he had planned for execution the present winter, a research upon the spectra of other non-metallic gases, in the hope that some of these, too, would be found represented as bright lines in the sun spectrum.

In 1878, he was the director of a party organized by himself to observe the total eclipse of the sun of the 29th of July. His familiarity with the locality led him to select Rawlins, Wyoming, an important station on the Union Pacific Railway, as the objective point. The result justified his selection. The expedition was entirely successful, and the observations which were made were of great value. By means of his splendid apparatus, Dr. Draper himself obtained an excellent photograph of the corona and also a photograph of its diffraction spectrum which was apparently continuous. In 1880, he obtained a number of spectra of Jupiter in connection with stellar work. On examining one of these spectra, the photograph appeared to him to show that the planet really furnished a certain amount of intrinsic light. The exposure on Jupiter was fifty minutes, the spectrum of the moon being taken in ten. The original negative was sent over to his friend, Mr. A. C. Ranyard, who presented it to the Royal Astronomical Society. In June, 1881, he took several excellent photographs of the comet, and also of its spectrum. With a slit and two prisms he obtained three photographs of the spectrum, with exposures of 180, 196, and 228 minutes, respectively. On each plate, a comparison spectrum was also photographed.

Upon the organization of the United States Commission to observe the Transit of Venus in 1874, Dr. Draper's great attainments in celestial photography pointed him out at once as the man best suited to organize the photographic section, and he was accordingly appointed Director of the Photographic Department. He went at once to Washington, entered heartily into the work, and during three entire months devoted himself to the labor of organizing, experimenting and instructing; declining subsequently all compensation for the time thus spent. Although his duties at home prevented him from joining any of the expeditions, yet so instrumental had he been in making the transit observations a success, that upon the recommendation of the Commission, Congress ordered a gold medal to be struck in his honor at the Philadelphia Mint. This medal

is 46 millimeters in diameter. It has the representation of a siderostat in relief upon the obverse, with the motto: "Famam extendere factis, hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M. D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

Professor Draper was appointed, in 1861, Surgeon of the Twelfth Regiment of New York Volunteers; a position which he accepted and in which he served with credit. In 1876, he was made one of the Judges in the Photographic Section of the Centennial Exhibition. In 1875, he was elected a member of the Astronomische Gesellschaft. In 1877, he received an election to the National Academy of Sciences; and in the same year he was made a member of the American Philosophical Society. In 1879, he was elected a Fellow of the American Association for the Advancement of Science. In 1881, the American Academy of Arts and Sciences worthily enrolled him among its members. In 1882, the University of Wisconsin and the University of New York conferred on him, almost simultaneously, the degree of LL.D.

For several years it had been Dr. Draper's custom to join his friends, Generals Marcy and Whipple, of the Army, in the early fall, for a few weeks' hunting in the Rocky mountains. In 1882, the party left New York on the 31st of August, went by rail to Rock creek, on the Union Pacific Railway, and from there went north in the saddle; reaching Fort Custer, on the Northern Pacific Railway, near the middle of October. During the two months of their absence the party rode fifteen hundred miles on horseback, as Dr. Draper estimated. When above timber line early in October, they encountered a blinding snow storm with intense cold and were obliged to camp without shelter. Dr. Draper reached New York on the 25th of October. Ordinarily, he returned refreshed and invigorated with the splendid exercise of the trip; but this year the distance traveled seemed to have been too great, and this, together with the hardships encountered, seemed to have wearied him. Pressure of delayed business awaited him and occupied his time at once. Moreover, the National Academy was to meet in New York in November; and he was to entertain them as he had always done. This year the entertainment was to take the form of a dinner. In order to offer them scientific novelty, he determined to light the table with the Edison incandescent light, the current being furnished from the machine in his laboratory. But the source of power being a gas engine, and therefore intermittent, a disagreeable pulsation was observable in the light. To obviate this he contrived an ingenious attachment to the engine whereby at the instant at which the speed was accelerated by the explosion of the gas in the cylinder, a lateral or shunt circuit should be automatically thrown in, the resistance of which could be varied at pleasure. With his admirable mechanical skill he extemporized the device from materials at hand and found it to work perfectly. The dinner was given on the evening of November 15th, and was one of the most brilliant ever given in New York; about forty academicians, together

with a few personal friends as invited guests, sitting at table. But Dr. Draper's overwork now told upon him; slightly indisposed as he had been before, he was unable to partake of food, and a premonitory chill seized him while at the table. As soon as the dinner was over, he took a hot bath, thinking thus to throw it off. But while in the bath a second and severer chill of a decidedly congestive type attacked him, and it was only with the greatest difficulty that he could be carried to his bed. His warm friend and former colleague, Dr. Metcalfe, was at once summoned and pronounced the attack double pleuritis. The best of treatment and the most careful nursing seemed for two or three days to be producing an effect for the better. But on the Sunday following, heart complication developed and he died about 4 o'clock in the morning of Monday, the 20th of November.

Viewed from whatsoever standpoint, the life of Henry Draper appears as successful as it was earnest, honest and pure. His devotion to science was supreme; to him no labor was too severe, no sacrifice too great, if by it he could approach nearer the exact truth. The researches he had already made, and much more those he had projected, involved the largest expenditure of his time and means. But such was his delight in his scientific work, and his enthusiasm in carrying it on, that he was never happier than when hardest at work in his laboratory, never more cheerful than when most zealously laboring with his superb telescopes. Moreover, he was as eminent as a teacher of science as he was as an investigator. His lectures were simple, clear and forcible. They held the interest of the class and awakened their enthusiasm while they enriched the student's store of knowledge and strengthened his powers of observation and of reason. In the laboratory he was keen, thorough and impartial, while at the same time considerate and helpful; ever striving to encourage honest endeavor and to assist the earnest worker.

Still another sphere of labor, however, made demands upon his time. In 1867, he married Mary Anna, the accomplished daughter of Courtlandt Palmer, of New York. Upon Mr. Palmer's death, in 1874, Dr. Draper became the managing trustee of an immense estate and, with his characteristic energy and efficiency, entered at once upon the task of reducing it to a basis of maximum production with the minimum amount of attention. The responsibility which thus rested upon him, the harassing demands of tenants, the endless details of leases, contracts and deeds, and the no less annoying complications of necessary law suits, worried him incessantly. And had it not been for his unsurpassed business capacity, he might have failed. But he was equal to the demand upon him, and within a few years, order had come out of confusion, and a few hours at his office daily enabled all to flow along smoothly.

To indicate the esteem in which Dr. Draper was held by his confrères in science, the following passages may be quoted from an excellent biographical notice of him written by Professor Young, of Princeton: "In person he was of medium height, compactly built, with a pleasing address,

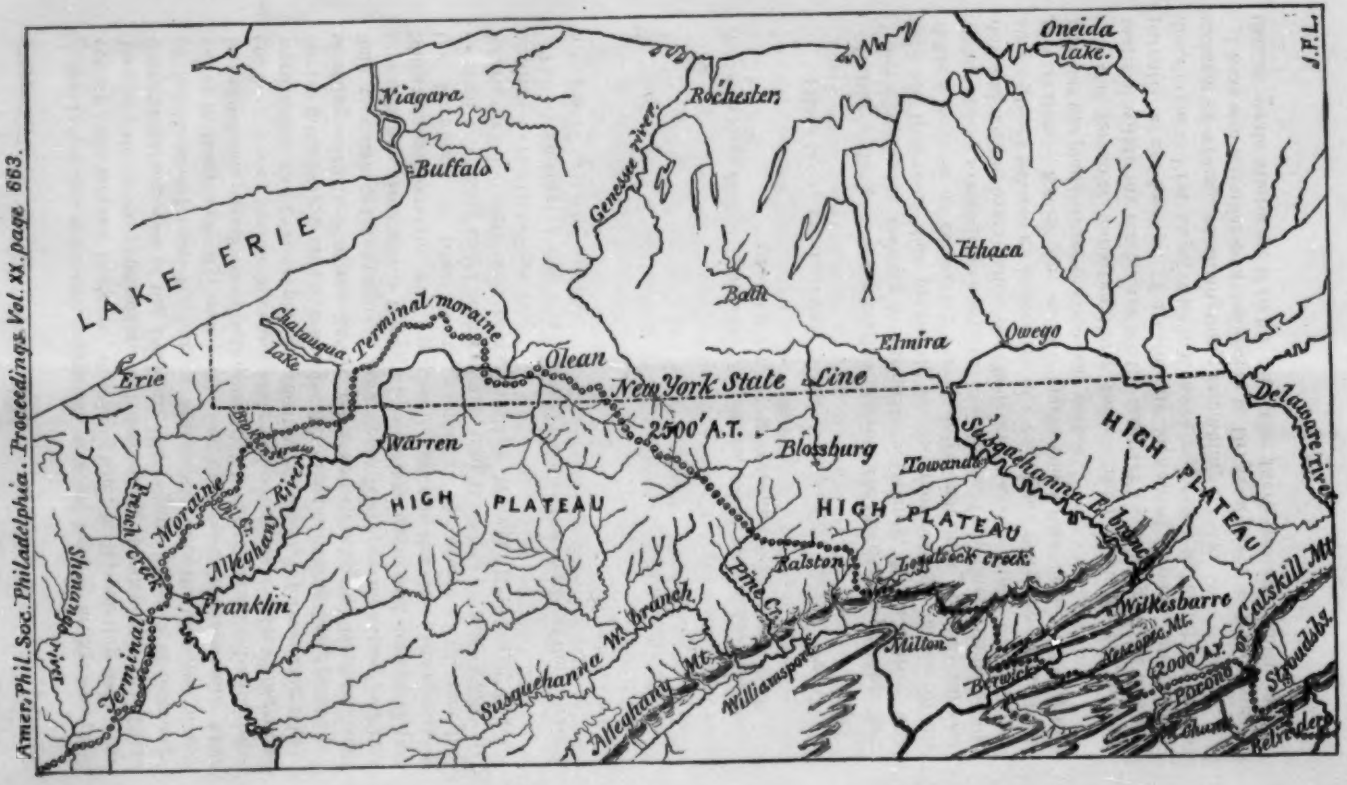
and a keen black eye which missed nothing within its range. He was affectionate, noble, just and generous; a thorough gentleman, with a quick and burning contempt for all shams and meanness; a friend most kind, sympathetic, helpful, and brotherly; genial, wise and witty in conversation; clear-headed, prudent and active in business; a man of the highest and most refined intellectual tastes and qualities; a lover of art and music, and also of manly sports, especially the hunt; of such manual skill that no mechanic in the city could do finer work than he; in the pursuit of science, able, indefatigable, indomitable, sparing neither time, labor nor expense."

"Excepting his early death, Dr. Draper was a man fortunate in all things; in his vigorous physique, his delicate senses, and skillful hand; in his birth and education; in his friendships; and especially in his marriage, which brought to him not only wealth and all the happiness which naturally comes with a lovely, true-hearted and faithful wife, but also a most unusual companionship and intellectual sympathy in all his favorite pursuits. He was fortunate in the great resources which lay at his disposal, and in the wisdom to manage and use them well; in the subjects he chose for his researches and in the complete success he invariably attained."

Such a man as this it is whose name we are sorrowfully called upon to strike from the roll of our living membership. Professor Draper was a man among men, a scientist of the highest type. Stricken down in the midst of his life-work, at the early age of 45, the bright promise of his noble life is left unfulfilled. What brilliant researches in his favorite science he would have made, we can never know. But with a mind so richly endowed and so thoroughly trained, with an experimental ability as earnest as it was persistent, with facilities for investigation which were as perfect as they are rare, with abundance of time and means at his disposal, and above all, with a devoted wife, who keenly appreciated the value of his scientific work, was ever at his side as his trusty assistant and always shared in the glory and the honor of his discoveries, we may be sure that, had he been permitted to reach the age of his honored father, results would have been reaped by his labors which would have added still brighter lustre to the science of America.

Map of the Terminal Moraine.

On page 476 it is recorded in the minutes of the meeting, October 6, 1882, that Prof. Henry Carvill Lewis read a paper on the course of the great Terminal Moraine through Pennsylvania, studied by him as volunteer Assistant of the Second Geological Survey of Pennsylvania, and described in his unpublished Report of Progress, Z, illustrated by photograph pictures taken by Mr. E. B. Harden, Topographical Assistant to the Survey.


Amer. Phil. Soc. Philadelphia. Proceedings Vol. xx. page 663.
J.T.L.
Oneida lake.
Niagara
Rochester
Buffalo
Genesee river
LAKE ERIE
Ithaca
Bath
Elmira
Owego
Chatauqua lake
Terminal moraine
Olean
Erie
New York State Line
2500' A.T.
Warren
Blossburg
Towanda
Susquehanna R. branch
HIGH PLATEAU
Delaware River
Allegheny R.
Franklin
Shenango river
Terminal moraine
Ralston
Loyalsock creek
Wilkesbarre
Pine Cr.
Susquehanna W. branch
Allegheny Mt.
Williamsport
Milton
Berwick
Nescopeck Mt.
2000' A.T.
Pocono
Catskill Mt.
Stroudsburg
Belvidere

Mr. Lewis described the hummocks west of Bangor in Northampton county; the striated boulders; the clay plain; S. W. pointing striæ near Bangor; the moraine ascending and descending the slopes of the Kittatinny mountain, west of the Delaware Water gap; boulders, 30 feet long, of fossiliferous Lower Helderberg limestone, from the outcrop in the valley in Monroe county, now perched on the crest of the mountain, 1400 feet above tide; boulders of well rounded Adirondack syenite from Northern New York; the moraine ascending to the summit and stretching westward across the Pocono plateau, 2000′ A. T. where it forms Long ridge, twelve miles long, a mile wide and 100 feet high; damming Long pond; descending to the bed of the Lehigh river, and crossing the Hazleton coal field mountains, Cunnyngham valley and Nescopec mountain and the Susquehanna river above Berwick; its curious ascent and descent of the Shickshinny mountain, with a perched boulder on the crest; the ascent of the Alleghany or Great North mountain; the course of the moraine through Lycoming and Potter counties into the State of New York; its return, and its south-west course through Warren, Butler and Beaver counties to the Ohio State line.

The accompanying map was prepared to show the course of the moraine with regard to the topography.

Note on a large Fish-plate from the Upper Chemung (?) beds of Northern Pennsylvania. By E. W. Claypole.

(*Read before the American Philosophical Society, April 6, 1883.*)

During a visit paid in the northern counties of this State in October last, I met a gentleman residing in Susquehanna county, Mr. A. Carter, who told me that some time previously he had ploughed up in one of his fields a large stone containing very peculiar markings upon its surface. Being unable to recognize it from his description, I requested him to send it down to me for examination on his return home. This he did, and a single glance showed an impression of a very large fish-plate in excellent preservation. Except one or two marks which had been made by the point of the ploughshare the cast was perfect.

It was, however, unlike anything which I had previously seen, and no material within my reach gave me the means of identifying it. It was apparently a nondescript. I accordingly forwarded a rough outline and description to Prof. Cope, who told me in reply that he could not at the moment of writing, recall anything resembling it.

I next sent a similar communication to Dr. Newberry, with the request that he would inform me if in his collection there was any similar speci-

men. In reply he told me that he thought he had fragments that might belong to the same species, but they were not sufficiently perfect for description. Feeling anxious to have Dr. Newberry's decisive opinion I next forwarded to him a photograph of the plate, asking if that would enable him to express an opinion whether the specimen belonged to a described or an undescribed species of fish. In reply he informs me that the fish in question is undescribed, but that he has some fragments of what he thinks is the same species, too imperfect for description.

Knowing that Prof. Whiteaves, Palæontologist to the Canadian Survey, had been working recently among some new Upper Devonian fishes, I sent him a photograph, requesting his opinion upon it. He has replied, saying, that there is no similar specimen among all those which he has seen from Scaumenac bay, and that he believes it is undescribed.

Description.

The specimen in question so far as the means at my command enable me to determine belongs to some species of the genus Pterichthys, or to some kindred genus, and is apparently the ventro-median plate. It is pentangular in outline but inequilateral, nearly symmetrical but not perfectly so. The front (?) is formed by one of the angles of the pentagon and the two sides enclosing this angle (of about 80°) are slightly concave outwardly. One of these sides—the right on the cast—is four and the other three and a quarter inches long. The former meets the third side of the pentagon at an angle of about 120°. This side is six and a quarter inches long. The latter meets at an angle of about 120° the fourth side of the figure which measures six and a half inches in length. The pentagon is closed at the base (back) by a short side of one and three-quarters of an inch long and very concave outwardly. The base is, in consequence of the inequality of the sides, slightly oblique.

The surface of the plate is marked with an ornamentation which I cannot find mentioned in the accounts of any other species. Instead of showing the tubercular or pustulose appearance of Pterichthys, its character more resembles (if we compare the great with the small) a magnified scale of Holoptychius. It is completely covered with close set interrupted wrinkles, slightly wavy, anastomosing and again separating without any appearance of regularity. These wrinkles meet the outside line almost at right angles and radiate inward in the following manner: If from the middle point of the axis of the plate straight lines be drawn to the upper (front) and two lower (back) angles, and lines, upwardly convex, to the lateral angles, the wrinkles in question start from these lines so as to meet the periphery (as said above) nearly at right angles. The wrinkles are subequal in size, largest anteriorly and posteriorly where they measure as much as one-eighth of an inch in breadth and are separated by furrows of about equal width. They increase slightly in size towards the periphery and in the middle are very small and much interrupted.

A flat, finely striate margin surrounds the whole plate, commencing at

the anterior angle where its breadth is nothing and widening to the lateral angles where its breadth equals half an inch. The outer line of this margin between the lateral and basal (?) angles is straight, giving its greatest breadth about the middle of these sides where it equals an inch. The margin of the basal side is about three-quarters of an inch in breadth in the middle. The whole of this margin is very finely striate nearly at right angles to the sides of the plate.

This margin is evidently the portion of the plate which was overlapped by the adjoining plates and in this respect the resemblance between it and the ventro-median plate of *Pterichthys oblongus* Ag. is obvious.

The outline of the plate corresponds very closely with that of the dorso-median plate of *Pterichthys*, and were it not perfectly flat I should be inclined to refer it to that part of the exo-skeleton. But this flatness renders it more probable that it represents the ventro-median or well known "lozenge-plate" of Hugh Miller—the central piece of the armor of this fish on the lower side—overlapped on all sides by others.

Prof. Whitcaves has very kindly lent me for comparison the original and only specimen of the ventro-median plate of his new species, *Coccosteus Acadicus*. This, much more closely than my specimen, resembles the ventro-median plates of *Pterichthys* and *Coccosteus*, as given by Hugh Miller in his "Old Red Sandstone." It is quadrilateral, with two outwardly concave and two straight sides. The ornamentation is very peculiar, the plate being "quartered" if we may borrow an expression from heraldry, and having crenulated ridges parallel to the outer side in the first and fourth quarters and irregularly scattered tubercles in the second and third. Altogether it shows little resemblance to the plate here described.

Prof. Newberry remarked in his letter that he very much doubted if the plate here described belonged strictly to *Pterichthys* and was inclined to consider it the type of a new genus. Probably this will be the result of a better knowledge of its structure, but it would be premature in this note to found a new genus on the fragments already known. When other parts of the exo-skeleton have been found it will be time to consider its generic position. Meanwhile I suggest for it the provisional name, PTERICHTHYS RUGOSUS.

The accompanying figure is taken from a photograph and will suffice to preserve the appearance of the specimen for future comparisons in the event of its loss or destruction.

On the Kingsmill White Sandstone. By E. W. Claypole.

(*Read before the American Philosophical Society, April 6, 1883.*)

Near the base of the red sandstones and shales which compose the Great Ponent series of Professor Rogers, lies a thin bed of white sandstone which promises to be of much interest, and perhaps of some importance in the

PTERICHTHYS? RUGOSUS, sp. n. UPPER CHEMUNG, PENNA. From a photograph of a plaster cast taken from the impression in sandstone.

PROC. AMER. PHILOS. SOC. XX. 113. 4F. PRINTED MAY 25, 1883.

geology of Perry county and of Middle Pennsylvania. In itself in nowise remarkable, it abounds in organic remains which when worked out will yield a rich fauna.

It is at present impossible to decide the *exact* horizon to which this sandstone belongs. For this reason, and to avoid prejudging the question, I have retained the term "Ponent." The transcendental nomenclature of Rogers is doomed to deserved extinction, but until we can determine finally what terms shall take the vacant places, it is wise to retain such of them as are necessary or convenient.

There is no question regarding the extent or signification of the term "Ponent" as employed by Professor Rogers. It is purely a lithological term, and is neither based on nor supported by palæontological evidence. In many parts of Middle Pennsylvania the dividing line which limits this Ponent Group is almost as easily seen in the rocks as on a geological diagram.

By the term "Ponent," Professor Rogers intended to designate all that great mass of red sandstone and shale, which intervenes between the top of his olive "Vergent" shales (Chemung of New York), and the Great Lower Carboniferous sandstone above them. The color and material of the beds are the sole foundations on which the distinction is based.

Palæontological considerations were not in the least regarded, partly because the time and means at the command of the First Survey forbade any extensive search for fossils, and partly because the great barrenness of these red shales and sandstones discouraged the same.

In New York, on the other hand, though fossils were also very scarce, yet an attempt was made by Professor Hall to establish a palæontological basis for his "Catskill Group," and the few relics that were obtained from the scanty exposures of these red shales and sandstones in that State were considered "characteristic." These are, strictly speaking, only two in number—*Holoptychius Americanus* and *Sauripteris Taylori*.

The base of the Catskill Group in New York is therefore double, lithological and palæontological. It may be to some extent an open question, whether or not these two horizons exactly coincide, and possibly the question may not admit of solution from the few and obscure exposures in that State. But until the coincidence of the horizons in New York with those in Pennsylvania is definitely settled, it would be premature to assume it. Consequently I retain for the present the term "Ponent" in writing of these beds.

The Kingsmill white sandstone lies near the base of these red sandstones and shales. Consequently it is in the Ponent Group of Pennsylvania. Its exact position is about 600 feet above the actual base of the red shales and sandstones. Palæontologically, the evidence leads to the same conclusion for about 400 feet below it are two fish-beds full of the remains of *Sauripteris* and *Holoptychius*. There is consequently no question of its position, judging from the data that have been hitherto accepted by geologists. Whether or not further examination of the Kingsmill sandstone will compel

some modification of these data time will show. As the lines of discrimination are now drawn, this sandstone must therefore be placed in the Ponent Group of Pennsylvania, and on palæontological evidence in the Catskill Group of New York. And no future changes can raise it. Any alteration, if made, can only lower it by placing it in the underlying or Chemung (Vergent) Group.

These details are necessary as an introduction to the facts and argument which follows.

Among the numerous fossils of the Kingsmill sandstone (many of which, though casts, are in excellent preservation, often showing the finest detail of structure), is one which at an early stage of the work arrested my attention. Its beautiful condition and the immense number in which it occurs were sufficient for this purpose. It is no exaggeration to say that at some of the exposures this fossil occurs in millions.

For some time I could get no clue to its name. At length, however, after going through with care all the material in my possession or within my reach, that bore upon the subject, I became almost certain that it was a fossil figured by Professor Hall in the geology of the Fourth District of New York, under the name *Cypricardia rhombea*. Possible inferences from this determination, however, deterred me from making use of the conclusion, and I laid the matter aside for further consideration.

Returning to the subject during the winter, while engaged in the study of my summer's collection, I found no reason whatever to distrust my previous determination, but in order to obtain the confirmation of another observer, I enclosed a specimen in a small parcel which I had occasion to send to Professor Whitfield, of the American Museum of Science, requesting his opinion on the identification. In his reply, he said:

"The shell sent is, I think, without question, *Schizodus rhombeus* Hall (*Cypricardia rhombea*) of the Fourth District Report. We have no really authentic specimens here, they being all in Professor Hall's hands at present."

In order to make the identification perfectly certain, I packed up a specimen, and sent it to Prof. Hall, with a request for his opinion upon it. In reply, he writes under date of March 10th, 1883.

"I do not perceive any important difference between the specimen sent, and *Schizodus rhombeus*, though I have not before had the casts of the interior, which I am glad to receive."

There remains therefore no doubt that the specimens here alluded to belong to the species *Schizodus rhombeus* Hall, of the Geological Report of the Fourth District of New York, where it was described and figured under the name of *Cypricardia rhombea*. It was found four miles north of Panama, Chautauqua county, New York, and attributed to the conglomerate at the base of the Carboniferous system. This opinion is now probably held by few or by no one. Prof. Hall said in the Twenty-third Regent's Report (p. 10):

"In the original collections of the Geological Survey, some of the con-

glomerates of the southern counties containing certain fossils were referred to and arranged with the Chemung Group, while those from other localities, but without fossils, were referred to Carboniferous age. This latter reference arose from finding some ferruginous beds supposed to be outliers of the red sandstone of Tioga, near the summits of some of the hills and below the conglomerates. These have since been proved by their contained fossils to belong to the Chemung Group, and it has not yet (1871) been demonstrated that the red sandstone of the adjacent part of Pennsylvania does occur within the limits of the south-western counties of New York.

"To a very great extent the conglomerates have been ascertained to belong to the Chemung Group, and to contain numerous fossils of that formation, while in some localities at least two hundred feet of shales and shaly sandstones, charged with Chemung fossils, lie above the conglomerates. So many localities have now been examined that we may conclude that all the conglomerates of the southern counties are of the age of the Chemung, but from the great difference in character of the fossils from different localities, it may not be regarded as proven that these beds are all of the same horizon.

"The relations of some of the outlying conglomerates south of Olean in New York and the adjacent parts of Pennsylvania in McKean county, to the Chemung Group and Coal Measures have not yet been satisfactorily determined."

Mr. Carll in Report III has given a minute account of the Panama conglomerate at its several exposures in Chautauqua county, New York, and has pointed out its peculiarities. He has also given a list of fossils obtained from it, which agrees, so far as the species were determined, with that given by Prof. Hall (Geol. 4th Dist. p. 291), except in one point. The following are the lists:

Prof. Hall's list.	Mr. Carll's list.
Euomphalus depressus	*Euomphalus depressus*
Cypricardia rhombea	*Cypricardia rhombea*
Cypricardia contracta	*Cypricardia contracta*
	Spirifer disjunctus

Mr. Carll does not give his locality, but as he describes a quarry four miles north of Panama, it may be inferred that he obtained some of them there. This is the locality mentioned by Prof. Hall.

One curious fact is the great discordance between the two accounts of the rock. Prof. Hall says:

"Fossils are exceedingly rare in this rock, having been seen in one locality only, four miles north of Panama."

Mr. Carll says:

"One of the exceptional features of the Panama rock is the great abundance of fossils found associated with it, and even in the pebble mass itself."

Probably, judging from the resemblance between the lists given above, the abundance of fossils is a local character of the rock. In this way we may perhaps reconcile the two accounts.

Without laying too much stress on a single species, it may be worth consideration whether or not the Panama conglomerate of Report III may be of approximately the same age as the Kingsmill white sandstone above described.

The following points of resemblance may be noted:

1. The Kingsmill sandstone is often conglomeratic.

2. The Kingsmill sandstone contains abundance of flat lenticular quartz pebbles. I have never seen a pebble of any other shape in it. This is a distinguishing feature of the Panama rock according to Mr. Carll and Mr. Ashburner.

3. The Kingsmill sandstones contain abundance of fossils, among which, in one locality at least, is found in profusion *Schizodus rhombeus*, one of the three characteristic species of the Panama rock.

The Sub-Olean or Sub-Garland conglomerate of Messrs. Carll and Ashburner is the only other conglomerate in that part of Pennsylvania holding similar flat pebbles. See Rep. III.

I have not yet identified with certainty either of the other three species mentioned by Prof. Hall and Mr. Carll to occur near Panama in the conglomerate, but so far as I have yet observed *Schizodus rhombeus* is strictly limited in Perry county to this single bed of sandstone not exceeding ten feet in thickness. A scarce form, usually imperfect, much resembles *S. contractus* (*Cypricardia contracta*), and may prove to be so. The Gasteropods are in so ill preserved a condition that their identification is attended with great difficulty.

If any importance be attached to this suggestion, it only remains to point out the horizon of the Kingsmill sandstone, which admits of no doubt, although it may admit of slight differences of opinion. As mentioned at the beginning of this note, it lies near the base of the great "Ponent" seriet. of Prof. Rogers. It must, therefore, be about the top of the Chemung or the base of the Catskill of New York, or perhaps better in what we may call the "Chemung-Catskill passage beds." It is not probable that the palæontological evidence, when complete, will warrant the placing of this sandstone and its associated strata fully within either of these two great groups of New York.

The Kingsmill standstone cannot of course be a continuation, unchanged, of the Panama conglomerate for, according to the testimony of Mr. Carll and Mr. Ashburner, the latter graduates down into soft shales when followed a few miles to the south-east of Panama. But it may be a bed on the same or nearly the same horizon, and the deposit of a sea tenanted by the same species. It may even be a continuation of the same bed taking on its sandy nature again in consequence of changed conditions.

It only remains to add that, though the three or four species above enumerated form the whole of the known fauna of the Panama conglomerate*

* The list of fossils from the Panama conglomerate or its associated conglomerates has apparently been increased since the publication of the Geology of New York, by the addition of the following three species:
Edmondia æquimarginalis = *Cardinia æquimarginalis* Win.
Allorisma Hannibalensis = *Grammysia Hannibalensis* Shumard.
Sanguinolites clavulus Hall.

in New York, yet the Kingsmill sandstone contain a rich fauna, the names of which will form, when worked out, a long list.

In addition to what has been said above concerning the fossils of the Panama conglomerate, the following notes are worthy of a little space.

Prof. A. Winchell in a paper printed in the Proceedings of the Acad. of Nat. Sciences, 1865, says, when speaking of the fossils of the Marshall Group of Michigan:

"Perhaps the most interesting feature of all is the identification of four Western species with fossils contained in the supposed Carboniferous conglomerate of Western New York. These are:

Euomphalus depressus Hall = *Straparollus Ammon* White.
Cypricardia contracta Hall = *Edmondia bicarinata* Win.
= *Sanguinolites rigidus* Win.
= *Cypricardia rigida* White and Whitf.
Edmondia æquimarginalis Win.
Allorisma Hannibalensis Shum.

"Further than this, two of the above species—*E. æquimarginalis* and *Allorisma Hannibalensis*—occur in what has been regarded as another conglomerate whose position is beneath the first, and at the top of the Chemung rocks of Western New York."

In regard to this last remark, Mr. Ashburner in Report III, pp. 70–79, says that the Panama conglomerate is the lowest sandstone in the N. W. of Pennsylvania and S. W. of New York. He says that an oil well sunk close to the base of the Panama rock passed through 1200 feet of soft shale and slate, and that other wells in the region gave similar sections. He says that, granting all the conglomerates cropping out and forming rock-cities along the State line hills to be distinct beds, they lie thus:

1. Olean (Garland = Sharon = Ohio).
2. Sub-Olean, Sub-Garland, Shenango.
3. Tunangwant.
4. Salamanca.
5. Panama.

On his view, therefore, there is no older conglomerate than the Panama in the region.

Prof. Winchell argues that because these four species occur in the Marshall Group in Michigan, and in the Panama (or its equivalent) conglomerates of New York, therefore the Marshall Group is more or less the equivalent of these conglomerates which he assumes to be of Lower Carboniferous age as stated in the Geology of New York. Consequently, he infers that the Marshall grits and conglomerates of Michigan are of Lower Carboniferous age. The evidence given above, shows that one of the species of the Panama conglomerate is not Lower Carboniferous, but belongs at the base of the Catskill. The other species may be found in the same horizon. The inference from this datum, somewhat slender it is true, is

that the Panama conglomerate belongs to the base of the Catskill, and probably also the Marshall grits of Michigan.

No representative of the Catskill has yet been found or recognized so far as I am aware in Michigan. A gap is left in the Michigan section between the Chemung and the Lower Carboniferous.

Mr. Lesley remarked on this paper of Prof. Claypole's, that he could not agree with the sentiment expressed in its introduction respecting the doubtful propriety of the use of the term "Catskill formation" as an equivalent of Prof. Roger's "Ponent formation."

It is a mistake to suppose that the "Catskill formation" was based in any degree upon fossil forms, any more than was the "Ponent." The two terms are completely and exactly identical. The New York geologist meant by it the red rocks constituting the Catskill Mountain massif, overlooking the Hudson valley, and extending unbroken far into Pennsylvania, and in fact through Pennsylvania into Maryland and Virginia. It was described as a pile of nearly horizontal Devonian strata destitute of fossils remains, except a few macerated plants and one or two types of fish. Mr. Rogers had to describe the same mass of strata, with the same lithological constitution and topographical aspect, and perfectly continuous with it geographically. There never was any question, nor is there now any question of the identity of this mass of strata in the two States. But as Mr. Rogers declined to accept any of the Palæozoic names of New York and invented a new nomenclature for his own use in Pennsylvania, he substituted *Ponent* for "Catskill," as he substituted *Medidial* for "Oriskany," *Postmedidal* for "Upper Helderberg," *Cadent* for "Hamilton," *Vergent* for "Chemung and Portage," &c. The only essential change he made was in giving a separate name, *Vespertine*, to the gray sandstone strata forming the *peaks* of the Catskill. These had been left unnamed (or included under the general name "Catskill") because the N. Y. geologists had no clue to their topographical significance, which only appears after passing west of the Lehigh, where, upturned vertically, they constitute a separate range of mountain.

In the reports of the Second Geological Survey the transcendental nomenclature of the brothers Rogers has been set aside in favor of the older, classical and generally accepted nomenclature of the New York geologists. As the gray sands of the Catskill peaks form the top coating of the Pocono tableland in Pennsylvania, the name "Pocono" has been substituted for *Vespertine;* but this leaves the term *Ponent* represented, as it always has been, by "Catskill."

The discussion in New York respecting the lower limit of the Catskill formation (recently settled by the proper placing of the Oneonta sandstone) has always left the great Catskill formation unaffected. So in Pennsylvania, the 100′ of transition beds at the bottom of the *Ponent* and at the top of the *Vergent*, do not affect in the least the broad fact that *Ponent* is "Catskill" and *Vergent* is "Chemung." No palæontological discoveries can ever alter these established relationships.

The discovery of Catskill fish-forms down in the Chemung has no more bearing on the name "Catskill" than it has on the name *Ponent;* for "Catskill" and *Ponent* are merely synonyms for the 3000′ + of red and gray sands and shales of the Catskill-Pocono-Alleghany mountain range which present a continuous outcrop from the Hudson to the Potomac.

The discovery of Catskill fish-forms down in the Chemung merely adds one more item of evidence to the now almost accepted conviction that the task of devising geological names of the first and second order cannot safely be entrusted to palæontologists, but that they must limit their function as namers of strata to names of the third and fourth order, as the geologists of the continent of Europe have been content to do for some years back, designating the groups of beds in a subdivision of a formation by some characteristic fossil form; as, for instance:—Trias; 1. Grés bigarré; 1. b. *Grés à Woltzia.* The fact is becoming patent to all eyes, that the occurrence of special fossil forms in a rock is no evidence of the exact age of that rock until after its exact age has been settled topographically or structurally.

If then the new fish-form be a Catskill fish found in Chemung rocks, it will not make the upper part of the Chemung, Catskill. It merely happens that a Chemung fish is also a Catskill fish. And so of any other fossil form discovered under similar circumstances.

Mr. Lesley added that the discovery of the Kingsmill White Sandstone fossils by Prof. Claypole is important for the future settlement of the question: What becomes of the Catskill formation going west into Western New York, Ohio and Michigan? If we could trust the evidence of fossil forms for establishing a lithological horizon — if we were sure that there were an immovable horizon extending more than 500 miles (S. E. and N. W.) characterized by Hall's *Euomphalus depressus*, and *Cypricardia contracta*, Winchell's *Edmondia æquimarginalis*, and Shumard's *Allorisma Hannibalensis*—and if this horizon be seen at Marshall in Michigan just under the *Coal measures*, at Panama in Western New York considerably below the *Venango Oil measures*, and in Perry County, Middle Pennsylvania, just below the bottom of the great *Catskill formation*—everybody who believes in this kind of evidence must accept the conclusion that there is a *time gap* in the Michigan and Northern Ohio section to be measured by many thousand feet of Pennsylvania strata, the majority of which are Catskill; and that this gap happens between the "Marshall grit" of Michigan and the next overlying strata.

But the fact must be kept in view, that no interval of time can elapse between emergence and resubmergence, without the interval being accented by erosion which has gone on during the interval. If the time interval in question extended through the Catskill era, Michigan standing above sea level, there should not only be a plane of paleontological nonconformity, but also nonconformable bedding; and, in soft Devonian measures, this would be deeply sculptured. None such being known in Michigan, we must conclude that the time-interval was spent *under water;* but in that case sedimentation must have gone on. We are therefore shut up to the conclusion that several thousand feet of Perry County, Pennsylvania, deposits are represented by a few yards, feet, or perhaps only inches of Michigan rocks; yet nevertheless perfectly and conformably represented.

Early Records of the Society.

Mr. Lesley, in reporting the completion of his MS. Condensed Copy of the Minutes of the Society, upon which he has been engaged, at intervals, during the last two years, said:

These Minutes, preserved in ten volumes, commence with Franklin's letter of 1744, and reach to the last meeting in December, 1837, after which the Proceedings were regularly printed for the use of the members, at first four times, and then twice a year, the first issue of 1838 being numbered 1, and the last issue of 1882, 112.

Vol. I,	1838, 1839, 1840, contains	Nos. 1 to 14.
Vol. II,	1841'3, contains	Nos. 15 to 26.
Vol. III,	Celebration of the Hundredth Anniversary,	No. 27.
Vol. IV,	1845'7, contains	Nos. 28 to 39.
Vol. V,	1848 to 1853—	Nos. 40 to 50.
Vol. VI,	1854 to 1858—	Nos. 51 to 60.
Vol. VII,	1859 to 1860—	Nos. 61 to 64.
Vol. VIII,	1861, contains	Nos. 65 and 66.
Vol. IX,	1862 to 1864—	Nos. 67 to 72.
Vol. X,	1865 to 1868—	Nos. 73 to 80.
Vol. XI,	1869 and 1870—	Nos. 81 to 85.
Vol. XII,	1881 and 1872—	Nos. 86 to 89.
Vol. XIII,	1873 and 1874—	Nos. 90 and 91.
Vol. XIV,	1875, contains	Nos. 92 to 95.
Vol. XV,	1876, contains	No. 96.
Vol. XVI,	1876 and 1877, contains	Nos. 97 to 99.
Vol. XVII,	1877 and 1878—	Nos. 100 and 101.

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Vol. XVIII,	1878 to 1880—	Nos. 102 to 106.
Vol. XIX,	1880 and 1881—	Nos. 107 to 109.
Vol. XX,	1881'2'3—	Nos. 110 to 113.
Vol. XXI,	1883, June onward,—	No. 114.

I propose that as a substitute for Vol. I, now out of print, the Society shall print a Vol. I, beginning in 1744 and containing the condensed Minutes of ninety-six years, *i. e.*, up to the beginning of 1841, thus including a condensed reprint of the present Vol. I.

The MS. which I lay on the table consists of reports of the Proceedings of every stated, adjourned or special meeting in more than seventy years, *condensed;* omitting nothing of the nature of an act or fact however unimportant, but stating it in the fewest possible words, and using a certain number of easily understood contractions, such as Soc., Lib., Don., Com., for Society, Library, Donations, Committee, &c., in order to get as many paragraphs as possible to occupy each not more than one line of printed text.

Another means made use of for diminishing the bulk of the MS. was the omission of all titles and initials to proper names, except in cases where the title or initial was needful to distinguish one individual from another of the same name.

With the same object in view, the lists of members present at meetings subsequent to 1800 are only given on important occasions, or at times when the Society was specially active or specially inactive, or after numerous admissions of new members, or at elections, or during debates protracted from meeting to meeting.

Much space was saved, and great clearness given to the record, for consultation, by ignoring most of the prolix formality and tedious verbiage of both minutes and resolutions. Short formulæ were adopted for many of the constantly recurring proceedings, such as references to and reports from committees. But resolutions of the slightest financial or historical importance are given *verbatim;* and where they are contracted or condensed, the essential wording is retained, and every word or sentence in the original is furnished in the copy with *quotation marks*, to obviate the necessity of reference to the original for the purpose of verifying the real meaning of the transaction.

Quotation marks are used throughout the copy, and by these the completeness of the copy as well as its fidelity, can be judged.

All unusual spellings of words and names are followed by the signal (*sic*). Many of the names of members are spelled by different Secretaries, in different years, and in the same year, in two or more ways; as for example: Lesueur, Le Sueur, Le Seur; Beesley, Beasley; Du Ponceau, Duponceau; Nicholls, Nicolls, Nichols; Pennington, Penington; and even Vaughan, Vaughn. Many of these variations are not due to careless transcription, but to unestablished orthography. This is especially apparent in the lawless variations in the use of initial capitals, especially in the ear-

lier years. All these curious features of our minute books have been sedulously retained in making the copy.

All annotations are placed in brackets.

Side notes, corrections and blanks are noted.

Thirty or forty blank pages have been left, in different parts of the mass of copy, to be filled by a literal copy of the original MS. in such cases as the letters of Jefferson, or long resolutions, every word of which should be retained. This filling-in can be done by a careful copyist at any time previous to the publication of the copy, or while it is going through the press.

For nearly fifty years the records of the earlier years of our Society have stood exposed to destruction, especially by fire; and it is surprising that a copy of them has never been made before now. The present copy is preserved by the President in the fire-proof vault of the Western Saving Fund Society, Walnut and Tenth streets, to be forthcoming at the order of the Society.

Its publication would not only secure it against destruction, but would no doubt give lively satisfaction to the members of the Society, who would then for the first time be able to gratify a natural and affectionate curiosity respecting the origin, growth, struggles and labors of the venerable institution to which they belong. Most of the names of noted Philadelphians appear in these minutes, and many famous men of other States, and of foreign countries.

Not the least important feature of the record is its representation of the first appearance of potent ideas; the first efforts for the improvement of the mechanic arts; the first steps taken in scientific paths; early explorations of the New World; with a pronounced eagerness to import the faculties of the Old World into it. It is not so much a record of the growth of an American Society, as a record of the growth of society in America, and in this sense alone it possesses an extraordinary historical value.

If printed, it will make a volume of about 400 pages, and can be cursorily read through at two or three sittings. The reader will probably feel what the biologist feels while spending some hours in watching, through his microscope, the metamorphoses of one of the protozoa.

The printing will be cheap, as it is all plain copy, and will require little or no correction.

It should be printed as one of our set of Proceedings; and entitled "The Proceedings of the American Philosophical Society, Vol. I, Part I, from 1744 to 1838," or simply Vol. I, 1744 to 1848. It will then be placed by corresponding societies and libraries in its proper place at the beginning of the row of our Proceedings, the present Vol. I, will be recognized (even without reprinting its title page) as Vol. I, Part II. But it would be well for the Society to print an extra title page, to go out with it, and be pasted by our correspondents over the old title page of Vol. I, designating that as Part 2.

The principal use of this volume, *well indexed*, will be for referring to the

past action of the Society on subjects of order and discipline, ownership of property, and financial investments, which have always necessitated references to the written minutes tedious and often unsatisfactory. Also, when questions arise as to the ownership and history of the objects of art and books in the possession of the Society, this printed record will be found convenient.

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him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve Councillors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notic shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a

short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of———A.D.———." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the Treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The Treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for the addition, to the said premium, of such amount as the Society may from time to time think suitable, or for the institution of other premiums.

The Treasurer shall, at the first stated meeting of the Society in the month of December, annually, make a report of the state of said fund and of the investment thereof.